FOR OFFICIAL USE.

REPORTS

TO THE

LOCAL GOVERNMENT BOARD

ON

PUBLIC HEALTH AND MEDICAL SUBJECTS.

(NEW SERIES No. 16.)

Further Preliminary Reports on Flies as Carriers of Infection :—

1. Memorandum on Lines of Investigation : by Dr. Copeman.
2. Notes on Colouring Flies for Purposes of Identification : by Mr. Jepson.
3. Preliminary Note on Examinations of Flies for the Presence of *Bacillus Coli* : by Dr. Graham-Smith.
4. Abstracts of Literature and Bibliography : by Professor Nuttall and Mr. Jepson.

LONDON :
PRINTED FOR HIS MAJESTY'S STATIONERY OFFICE,
BY DARLING & SON, LTD., 34–40, BACON STREET, E.

And to be purchased, either directly or through any Bookseller, from
WYMAN & SONS, LTD., FETTER LANE, E.C. ; or
OLIVER & BOYD, TWEEDDALE COURT, EDINBURGH ; or
E. PONSONBY, 116, GRAFTON STREET, DUBLIN.

1909.
Price Threepence.

Further Preliminary Reports on Flies as Carriers of Infection :—

1. Memorandum on Lines of Investigation : by Dr. Copeman.
2. Notes on Colouring Flies for Purposes of Identification : by Mr. Jepson.
3. Preliminary Note on Examinations of Flies for the Presence of *Bacillus Coli* : by Dr. Graham-Smith.
4. Abstracts of Literature, and Bibliography : by Prof. Nuttall and Mr. Jepson.

Arthur Newsholme,
Medical Officer,
17th September, 1909.

---

1. Memorandum by Dr. Copeman on Investigation into Possible Carriage of Infection by Flies. Suggested "Plan of Campaign" in Urban Districts.

In order that the results of investigations carried out at different places may be as strictly comparable as possible, it is desirable that all observations should be conducted, so far as local circumstances permit, on similar lines ; for which reason, and with the object of securing really comparable data, the following scheme is submitted.

Observation "Centres" and Fly-collecting "Stations."

First and foremost a number of separate "centres" must be selected, around which, at varying distances, and at different points of the compass, it will be necessary to establish stations at which flies are to be collected.

As regards these collecting stations, which will in most cases consist of private houses, it is obviously necessary that the co-operation of the occupiers of the premises must be obtained ; but experience in London and elsewhere has shown that no difficulty is likely to be experienced in this respect, householders, as a rule, being only too glad to avail themselves of the benefit of having their rooms freed from flies, without expense to themselves.

LONDON:
PRINTED FOR HIS MAJESTY'S STATIONERY OFFICE,
By DARLING & SON, Ltd., 34-40, Bacon Street, E.

And to be purchased, either directly or through any Bookseller, from
WYMAN and SONS, Ltd., Fetter Lane, E.C. ; or
OLIVER & BOYD, Tweeddale Court, Edinburgh ; or
E. PONSONBY, 116, Grafton Street, Dublin.

1909.

No. 16.

(14009—21.) Wt. 12252—795. 2000. 10/09. D & S. A

As "centres" it is desirable to select places where large quantities of house refuse and other fermentable material, or stable manure, is deposited or allowed to accumulate, such as municipal depôts and job-masters' premises, or places where offensive trade processes are carried on. In the event of large numbers of cows being kept in confinement, a cow-shed might also be chosen as a "centre."

At varying distances, preferably about 50, 100 and 150 yards respectively, from each "centre" fly "stations" must be established. These should be at least half a dozen in number around each "centre," and, where possible, located especially at points of the compass *from* which and *to* which the prevailing wind blows.

As Dr. Hamer has pointed out in connection with investigations that have been conducted in London during the past two years, all operations should be carried out with as much uniformity as possible, for which reason endeavour should be made to secure, as places of observation, kitchens or living-rooms occupied by poor people. It is desirable, moreover, that the rooms in which fly-traps of one or another kind* are to be placed should be on the ground floor, fairly lighted, and preferably with a sunny aspect. Houses should be selected which are neither specially clean nor specially dirty. They should not have been "done up" within the previous six months. It will, of course, be necessary to avoid selecting houses in the neighbourhood of which there may be local accumulations of house-refuse or stable manure, or which are in the vicinity of shops where articles of food are sold or premises where refuse material of any kind capable of undergoing decomposition is stored.

In general it will probably be advisable to leave the actual selection of premises to the Sanitary Inspectors, to whom also (their other duties permitting) may be entrusted the placing and removal of fly-traps and the enumeration of the captured flies.

Fly-traps.

Both fly-papers, and traps of fine wire gauze, of rounded shape, generally known as "balloons," should be used side by side, whenever possible. The larger flies, such as blue-bottles, are often capable of escaping from fly-papers on which they may have settled. For these flies, however, the "balloons," when properly baited, appear to possess a special attraction, the more so after capture of the first few specimens, who, by their buzzing, evidently attract their fellows.

The fly-paper recommended (it being desirable for the sake of uniformity that the same makes should be used in all cases), which is known as "The Fly Cemetery," is coated with a specially tenacious "honey-gum." The paper, after being unfolded, should be hung vertically from the ceiling of the room or from a gas-bracket in some situation which, while not dark, is not directly exposed to sunlight. As a precautionary measure, in hot weather, the lower edge of the paper should be folded up on the sticky side,

---

* *See* below.

in order to avoid possible dripping of the material with which the paper is coated.

Bait for fly "balloons" should consist of a few grains of the coarsest brown sugar moistened with (but not dissolved in) a little stale beer.

When desired, samples of the fly-papers and "balloons" recommended will be sent to Medical Officers of Health on application being made to the Medical Department of the Local Government Board.

Collection and Enumeration of Flies.

At regular intervals of 24, 48, or at most 72 hours, the papers and balloons are to be removed, fresh ones being substituted for them before the collector leaves the house. To kill the flies caught in the "balloons" the readiest method is to place the trap under a bell-glass together with a pledget of cotton-wool, on which has been sprinkled a few drops of chloroform. Or the trap may be dropped bodily into a bucket of boiling water, in which case it will be necessary afterwards to turn out the dead flies on to a sheet of blotting paper to dry, before attempt at counting them is made.

Before actual counting is commenced the flies should be sorted out, as far as possible, into different species, for which purpose the illustrations and descriptions contained in the pamphlet recently issued by the Medical Department will be found of service. The numbers of each species in the particular "catch" should then at once be entered in a book kept for the purpose.

From the numbers thus obtained curves will subsequently be plotted, for comparison with curves representing incidence of deaths from epidemic enteritis, and also from enteric fever, in the event of this disease having been prevalent.

Range of Flight.

Much need exists for accurate information as to the distance, vertically as well as horizontally, to which flies can be traced from their breeding places; or from some spot, for instance, at which specially marked flies are intentionally liberated.

A paper by Mr. Jepson dealing with the marking of flies is appended.

Bacteriology.

In large towns especially, where expert assistance is likely to be available, observations on the bacteriology of flies, particularly of those caught in the enteric fever wards of hospitals or on premises invaded by epidemic enteritis, will obviously be of importance.

"Spot" Maps.

Maps will require to be prepared on which are shown the exact location of fly "centres" and observation "stations." On these same maps should be shown by means of dots the particular houses invaded by epidemic enteritis or enteric fever, respectively.

Meteorological Data.

These should include records of air and soil temperature, of rainfall, of direction and force of wind, and duration of bright sunshine. Persistence of rainy weather has a marked influence in reducing prevalence of flies; while, with a high atmospheric temperature and bright sunshine, flies tend rapidly to increase in presence of the necessary food-material required by them during the larval stage of their existence. In connection with prevalence both of flies and of epidemic enteritis it is also obviously important, when possible, to obtain graphic record of the 4 ft. soil temperature.

In the event of flies being trapped the species of which is unknown and local sources of information not being available, specimens should be packed in a match-box with soft tissue paper (*not* cotton-wool, which is apt to cause damage to the insects, whose legs, &c. become entangled in it) and despatched at once to Mr. E. E. Austen, British Museum (Natural History), South Kensington, London, together with a brief note as to the date, locality, and other circumstances of their capture.

S. Monckton Copeman.

July, 1909.

---

2. Notes on Experiments in Colouring Flies, for purposes of Identification. Conducted, under the direction of Prof. Nuttall, at the Quick Laboratory, Cambridge, during July and August, 1908. By J. P. Jepson.

The flies used for the experiments were captured by means of "fly-balloons," which were placed in two different bake-houses, and two grocer's shops. The most plentiful supply was obtained from the bake-houses, where the flies abounded in great numbers. It should be remarked that in each case the bake-house was situated in the yard of a public livery stable, which probably accounts for the presence of the flies in specially large numbers. The traps were collected each morning, and afterwards re-set with brown sugar, moistened with stale beer, which proved a very successful source of attraction. About 98 per cent. of the flies captured were *Musca domestica.*

The object of the experiments was to discover some method of marking the flies in large numbers, so that they could easily be identified later.

The experiments were only of a preliminary character, and conducted on a somewhat small scale. It is hoped shortly to carry out similar experiments on a larger scale.

In the first instance, a large number of flies were dusted with ordinary household flour. This method was suggested by the fact

that one often sees the flies present in mills quite white in colour. This, however, met with failure, as the flies soon shook themselves free of the flour. Next was tried rice starch powder, as it was thought that being a finer powder, it might adhere better than the flour. Equally futile results attended experiments with this method.

Subsequently, ordinary coloured black-board chalks were finely ground up with a pestle and mortar, and dusted on to the flies.

The dusting was accomplished by placing the balloon containing the flies in a paper bag, pouring in the ground-up chalk, and gently shaking it about. By this means the flies became completely covered with chalk, and immediately proceeded to clean themselves, commencing with the eyes. They never succeeded however in removing the chalk from the upper portion of the thorax, nor from the base of the wings.

A series of balloons were treated in the above fashion, with different coloured chalks, and the flies were then liberated, either in net cages, or about the laboratory.

Some of the flies liberated in the laboratory were, in one instance, still to be seen six days later, but for the most part they escaped through open windows and doors, and not being liberated in sufficient numbers, the results were not definite.

Those confined in large netting cages gave more satisfactory results. In these cages, the flies were practically under natural conditions, having a large open space, and plenty of light. The flies were fed with sugar and water.

For convenience the results are given in tabulated form, so that they may be seen at a glance.

*Experiments with coloured Chalks and Dyes.**

Colour ...	July 23.	July 24.	July 25.	July 26.	July 27.	July 28.
Dark Blue ...	50 flies dusted	Few	Few	None		
Red	50 flies dusted	Few	None			
Light Blue ...	50 flies dusted	Few	Few	Few	None	
White ...	50 flies dusted	Many	Many	None		
Yellow ...	50 flies dusted	Many	Many	Many	Few	Few
Violet ...	50 flies dusted	Many	Many	Few	None	
Rosin, Alcohol and Rice Starch.	50 flies dusted	Very few	None			
Orange G. Alcohol and Rice Starch.	50 flies dusted	Very few	None			

* These flies were liberated about the laboratory, but unfortunately not in sufficient numbers for the results to be at all definite.

Experiments with coloured Chalks. Flies confined in large Net Cages.

Colour.	30 July.	31 July.	1 Aug.	2 Aug.	3 Aug.	4 Aug.	5 Aug.	6 Aug.	7 Aug.
Net 1. —— Violet.	40 flies dusted. Fed on sugar and water.	9 dead (22·5 per cent.). 3 badly battered. Colour good.	6 dead (15 per cent.). Colour good.	2 dead (5 per cent.). Colour fading.	2 dead (5 per cent.). Colour very faded.	1 dead (2·5 per cent.). Colour gone.			
Net 2. —— Light Blue.	40 flies dusted and fed as in Net 1.	5 dead (12·5 per cent.). Colour good.	6 dead (15 per cent.). Colour good.	None dead. Colour fading.	1 dead (2·5 per cent.). Colour very faded.	5 dead (12·5 per cent.). Colour gone.			
Net 3. —— Yellow.	40 flies dusted and fed as in Net 1.	5 dead (22·5 per cent.). Colour good.	2 dead (5 per cent.). Colour good.	2 dead (5 per cent.). Colour good.	4 dead (10 per cent.). Colour fading.	None dead. Colour very faded.	1 dead (2·5 per cent.). Colour very slight.	11 dead (27·5 per cent.). Colour very slight at base of wings only.	Rest dead (27·5 per cent.). Colour gone.

The coloured flies, confined in nets, giving good results, the following isolated net experiment was also started:—

Date.	Mortality.	Per cent.	Remarks.
31st July ...	—	—	25 flies dusted with "*brick-red*" chalk.
1st August ...	5	20	Colour very good.
2nd ,, ...	3	12	,, ,,
3rd ,, ...	4	16	,, ,,
4th ,, ...	None	—	,, ,,
5th ,, ...	1	4	,, ,,
6th ,, ...	None	—	Colour growing fainter.
7th ,, ...	,,	—	Colour still distinct.
8th ,, ...	,,	—	,, ,,
9th ,, ...	2	8	,, ,,
10th ,, ...	2	8	,, ,,
11th ,, ...	None	—	,, ,,
12th ,, ...	,,	—	,, ,,
13th ,, ...	,,	—	,, ,,
14th ,, ...	4	16	,, ,,
15th ,, ...	3	12	,, ,,
16th ,, ...	None	—	,, ,,
17th ,, ...	,,	—	,, ,,
18th ,, ...	,,	—	,, ,,
19th ,, ...	1	4	,, ,,

It will be seen from the above table that the colour remained distinct for twenty days. This result is highly satisfactory, as it shows that the colour can remain upon the fly during the greater part of its normal adult existence. Why this "*brick-red*" chalk gave better results than the other chalks, it is difficult to say. Possibly some injurious property present in the other chalks was absent in this one.

In addition to coloured chalks various aniline dyes were used, either made up in the form of a powder with rice starch, or mixed with alcohol in the form of a spray.

For a powder, rosin and alcohol and orange G. and alcohol were mixed with rice starch, filtered, and dried. For a spray, fuchsine was mixed with alcohol.

The flies had a habit of cleaning themselves so thoroughly after dusting that it was thought advisable to employ something of a sticky nature which would hold the powder in its place.

For this purpose shellac was dissolved in alcohol, and in the first case applied before dusting, and in the second case after dusting. The latter method gave the more satisfactory results as regards the colour remaining, but there was a heavier mortality.

This may have been due to the spray being applied too thickly and consequently either stiffening the joints of the insects or else closing up the stigmata and as a consequence stopping respiration.

It was suggested that the feeding of flies upon a strong dye might possibly influence their colour, but this proved not to be the case. A number of flies were fed on sugar deeply stained with orange G, and although they fed readily upon the sugar, there was no obvious result after ten days.

The following are the results of spraying with a dilute varnish of alcohol and shellac and then dusting, and of dusting followed by spraying :—

Flies confined in Net Cages and fed with Sugar and Water.

—	5th Aug.	6th Aug.	7th Aug.	8th Aug.	9th Aug.	10th Aug.	11th Aug.	12th Aug.
1	30 flies sprayed with alcohol and shellac and then dusted with rosin, alcohol and rice starch.	4 dead (13·3 per cent.). Colour holding.	2 dead (6·6 per (cent.). Colour holding.	None dead. Colour gone.				
2	30 flies sprayed with alcohol and shellac and then dusted with orange G, alcohol and rice starch.	5 dead (16·6 per cent.). Colour holding.	None dead. Colour holding.	2 dead (6·6 per cent.). Colour holding.	None dead. Colour holding.	None dead. Colour gone.		
3	*50 flies sprayed with alcohol and shellac and then dusted with rice starch.	None dead. Colour poor.	2 dead (4 per cent.). Colour slight.	1 dead (2 per cent.). Colour very slight.	1 dead (2 per cent.). Colour very slight.	None dead. Colour gone.		
4	*12 flies sprayed with alcohol and shellac and then dusted with rice starch.	5 dead (41·6 per cent.). Colour poor.	1 dead (8·3 per cent.). Colour slight.	None dead. Colour slight.	None dead. Colour slight.	1 dead (8·3 per cent.). Colour slight.	None dead. Colour slight.	Rest dead (41·6 per cent.) Colour almost gone.

* In Lots 3 and 4 the powder was badly applied and did not adhere well, but was stuck in patches and was not easily observed from any distance. It could be seen on close examination.

Flies confined in "Fly-balloon" and fed on Sugar and Water. These flies were lightly *sprayed with Shellac.*

Date.	Mortality.	Per cent.	Remarks.
7th August ...	—	—	8 flies sprayed with alcohol and shellac and then dusted with rice starch powder.
8th " ...	None	—	Colour very good.
9th " ...	2	25	" "
10th " ...	None	—	" "
11th " ...	2	25	" "
12th " ...	None	—	" "
13th " ...	2	25	" "
14th " ...	None	—	" "
15th " ...	"	—	" "
16th " ...	"	—	" "
17th " ...	"	—	" "
18th " ...	"	—	" "
19th " ...	"	—	" "
20th " ...	2	25	" "

Flies confined in Net Cages and fed on Sugar and Water.

Aug. 10.	Aug. 11	Aug. 12.	Aug. 13.	Aug. 14.	Aug. 15.	Aug. 16.	Aug. 17	Aug. 18	Aug. 19.
20 flies dusted with rice starch and sprayed with alcohol and shellac.	14 dead (70 per cent.). Colour good.	4 dead (20 per cent.). Colour good.	1 dead (5 per cent.). Colour good.	1 dead (5 per cent.). Colour good.					
20 flies dusted with rice starch and sprayed with alcohol and shellac.	1 dead (5 per cent.). Colour good.	13 dead (65 per cent.). Colour good.	1 dead (5 per cent.). Colour good.	1 dead (5 per cent.). Colour good.	None dead. Colour good.	1 dead (5 per cent.). Colour good.	1 dead (5 per (cent.). Colour good.	None dead. Colour good.	2 dead (10 per (cent.). Colour good.
50 flies sprayed with Fuchsine and Alcohol.	12 dead (24 per cent.). Colour good.	16 dead (32 per cent.). Colour good.	8 dead (16 per cent.). Colour good.	5 dead (10 per cent.). Colour good.	3 dead (6 per cent.). Colour good.	None dead. Colour good	6 dead (12 per (cent.). Colour good.		

14th Aug.	15th Aug.	16th Aug.	17th Aug.	18th Aug.
50 flies dusted with rice starch powder, sprayed with alcohol and shellac, and liberated in Pembroke College bakehouse.	A few to be seen about.	None about.	None about.	None about.

17th Aug.	18th Aug.	19th Aug.	20th Aug.	21st Aug.	22nd Aug.
100 flies well dusted with pink chalk and liberated in the Pembroke College bakehouse.	Very many about.	Very many about.	Very many about.	Not so many about.	None about.

Results.

1. Coloured chalks gave satisfactory results, and of these colours *Yellow* and *Brick red* were the best, lasting in the first case for nine days and in second case 20 days.

2. Spraying with alcohol and shellac, and then dusting with rice starch powder was satisfactory *as long as the shellac was not applied too thickly.*

In the case where it was applied thinly the colour lasted 14 days.

3. Dusting with rice starch powder and then spraying with shellac and alcohol gives excellent colour, *but the flies must be allowed to clean their eyes before spraying, and then the spray must be applied thinly.* In this case the best result was 10 days.

4. The use of various aniline dyes did not prove satisfactory. With fuchsine the mortality was very large.

It was found no easy matter to arrive at the number of flies present in a "fly-balloon," as the flies were constantly changing their position. Even a rough estimate proved, on counting the flies when dead, to be very wide of the mark.

Some method was desired, therefore, whereby one could approximate as nearly as possible, the number of flies present without actually counting them.

The first method that suggested itself was that of determining the number of flies which made up a certain weight, *e.g.*, 1 gram.

This fact known, and if one also knew the weight of the balloon, when empty and when full of flies, one could deduce the number of flies present, by the difference in weight of the balloon.

The weight of a number of flies was ascertained in the following manner :—

Weight of funnel (empty) ... = 25·75 grams.
Weight of funnel (with 165 flies) = 27·3 grams.

165 flies weigh 1·55 grams, and 100 flies weigh ·94 gram or 1 gram nearly.

These flies were weighed dead and had been so for 24 hours. Possibly if they had been weighed fresh they would have been still nearer 1 gram.

F. P. Jepson.

---

3. Preliminary Note on Examinations of Flies for the presence of Colon Bacilli. By G. S. Graham-Smith, M.D., University Lecturer in Hygiene, Cambridge.

Methods.

Most of the flies were caught in fly-traps in various parts of London, and sent to Cambridge for examination. The flies were killed by placing the traps in bell-jars containing a few drops of chloroform on a pledget of cotton wool. Altogether 148 flies were examined. These flies have been divided into four classes, spoken of as house flies, mainly *M. domestica*, but probably including some

specimens of the genus *Spilogaster*, Small flies mainly, *Homalomyia canicularis*, Blue-bottles, including *Calliphora erythrocephala* and *vomitoria*, and *Stomoxys calcitrans*.

In 60 instances a fly was seized with sterile forceps, placed in a tube of lactose-bile-salt broth, and the tube well shaken. The surface organisms were thus cultivated. In 88 cases the intestinal contents were alone examined. The intestine was removed by seizing the thorax of the fly with one pair of forceps and the terminal segments of the abdomen with another. By gentle traction the intestine can easily be pulled out intact, and without coming into contact with the surface of the insect. A portion of the intestine was then cut off and emulsified in lactose-bile-salt broth. The broth was incubated at 37° C. for 24 hours or longer. Plate cultures were then made on Conradi-Drigalski medium, bile-salt neutral-red lactose agar, and ordinary agar. Colonies were picked off from these plates and pure cultures made. The staining reactions, morphology and motility of the organisms obtained were examined, and cultures made in broth, gelatine, milk, peptone water, and peptone water containing 1 per cent. of glucose, lactose, saccharose, dulcite, mannite, and dextrin.

In this series of experiments the intention was to ascertain what proportion of flies were infected with organisms of the colon-group, and no attempt was made to work out completely all the organisms belonging to this group which occurred in each infected fly.

Characters of the Organisms.

Altogether 35 lactose fermenting organisms of the colon group were isolated, 22 from surface cultures, and 13 from the intestines.

All these organisms had the following characters in common :— short—Gram negative, non-spore producing bacilli with rounded ends—greyish white colonies on agar—gelatin never liquefied—moist white or cream-coloured growth on potato—permanent acidity and clotting in milk. Most of them produced indol, and the majority showed some motility, especially in peptone water cultures.

Following MacConkey's classification of the lactose fermenting bacteria, these organisms may be divided according to their reactions, which are given in the following table, into four groups.

Group.	No. of cultures.	Glucose.	Lactose.	Saccharose.	Dulcite.	Mannite.	Dextrin.	Milk.	Indol.
I.	10	A+G	A+G	O	O	A+G	A	A+C	+
II.	6	A+G	A+G	O	A+G	A+G	A	A+C	+
III.	15	A+G	A+G	A+G	A+G	A+G	A	A+C	+
IV.	4	A+G	A+G	A+G	O	A+G	A	A+C	+

O = No change.
A = Production of acid without gas.
A+G = Acid and gas produced.
A+C = Acid and clotting.
+ = Positive reaction.

Ten (28·5 per cent.) [group I.] correspond in their fermentation reactions to *B. acidi lactici* (Hüppe), 6 (17·1 per cent.) [group II.] to *B. coli communis* (Escherich), 15 (42·8 per cent.) [group III.] to *B. neopolitanus* or *B. coli communior* (Durham), and 4 (11·4 per cent.) [group IV.] to *B. lactis aerogenes* (Escherich).

The following table indicates the distribution of these organisms.

Flies examined.	No.	Organisms found in groups.				Total.
		I.	II.	III.	IV.	
House flies	94	8	6	4	2	20 (21·2 per cent.)
Surface cultures	38	6	4	4	2	16 (42·1 „)
Intestine cultures	56	2	2	—	—	4 (7·1 „)
Small flies	38	2	—	8	—	10 (26 3 „)
Surface cultures	16	—	—	4	—	4 (25·0 „)
Intestine cultures	22	2	—	4	—	6 (27·2 „)
Blue-bottles	14	—	—	2	2	4 (28·5 „)
Surface cultures	6	—	—	—	2	2 (33·3 „)
Intestine cultures	8	—	—	2	—	2 (25·0 „)
Stomoxys calcitrans	2	—	—	1	—	1 (50·0 „)
Intestine cultures	2	—	—	1	—	1 (50·0 „)
Total surface cultures	60	6	4	8	4	22 (36·6 per cent.)
„ *intestine cultures*	88	4	2	7	0	13 (14·7 „)
Complete total	148	10	6	15	4	35 (23·6 per cent.)

Flies were obtained from the following sources :—(1) From the neighbourhood of decaying animal matter at Cambridge, (2) from a railway siding at Islington, at which manure was being loaded into trucks, (3) from a room used by the men of a gas-works, (4) from a house 40 yards distant from the Bermondsey glue works, (5) from the kitchen of a London County Council School, and (6) from a house about 50 yards distant from the Bermondsey jam factory.

The results of the examinations of the flies from each source is given in the following table :—

—	No. examined.	No. infected.	Organisms found in groups.				Remarks.
			I.	II.	III.	IV.	
(1) *From Cambridge* :							
House flies	10	6	—	—	—	—	
Surface cults. ...	4	2	—	2	—	—	
Intestine cults. ...	6	4	2	2	—	—	
Small flies	10	6	—	—	—	—	
Surface cults. ...	6	2	—	—	2	—	28 flies examined, 15 (54·5 per cent.) infected.
Intestine cults. ...	4	4	2	—	2	—	
Blue-bottles	6	2	—	—	—	—	
Surface cults. ...	2	—	—	—	—	—	
Intestine cults. ...	4	2	—	—	2	—	
Stomoxys	2	1	—	—	—	—	
Intestine cults. ...	2	1	—	—	—	—	

—	No. examined.	No. infected.	Organisms found in groups.				Remarks.
			I.	II.	III.	IV.	
(2) *From railway siding :*							
House flies	24	6	—	—	—	—	25 per cent. infected.
Surface cults. ...	12	6	2	—	4	—	
Intestine cults. ...	12	—	—	—	—	—	
(3) *From gasmen's room :*							
House flies	12	2	—	—	—	—	16·6 per cent. infected.
Surface cults. ...	4	2	2	—	—	—	
Intestine cults. ...	8	—	—	—	—	—	
(4) *From house near glue works :*							
House flies	10	2	—	—	—	—	26 flies examined, 4 (15 per cent.) infected.
Surface cults. ...	2	2	—	—	—	2	
Intestine cults. ...	8	—	—	—	—	—	
Small flies	10	—	—	—	—	—	
Surface cults. ...	4	—	—	—	—	—	
Intestine cults. ...	6	—	—	—	—	—	
Blue-bottles	6	2	—	—	—	—	
Surface cults. ...	4	2	—	—	—	2	
Intestine cults. ...	2	—	—	—	—	—	
(5) *From school kitchen :*							
House flies	4	—	—	—	—	—	18 flies examined, 4 (22·2 per cent.) infected.
Surface cults. ...	2	—	—	—	—	—	
Intestine cults. ...	2	—	—	—	—	—	
Small flies	12	4	—	—	—	—	
Surface cults. ...	4	2	—	—	2	—	
Intestine cults. ...	8	2	—	—	2	—	
Blue-bottles	2	—	—	—	—	—	
Intestine cults. ...	2	—	—	—	—	—	
(6) *From near jam factory*							
House flies	34	4	—	—	—	—	40 flies examined, 4 (10 per cent.) infected.
Surface cults. ...	14	4	2	2	—	—	
Intestine cults. ...	20	—	—	—	—	—	
Small flies	6	—	—	—	—	—	
Surface cults. ...	2	—	—	—	—	—	
Intestine cults. ...	4	—	—	—	—	—	
Total	—	—	10	6	15	4	—

So far as can be inferred from the small numbers hitherto examined, the highest degree of infection is found amongst the flies obtained from the neighbourhood of decaying animal matter, and the next highest amongst those caught near manure. Those from other situations show an approximately equal degree of infection with lactose fermenting bacteria of the colon group.

House flies, small flies, and blue-bottles were found to be infected in approximately equal numbers. Surface infection was two-and-a-half times more common than intestinal infection.

Attention was first confined to those coli-like organisms capable of producing acid and gas in lactose, but later certain other organisms were examined. Amongst these an organism of some interest was discovered, which was isolated on two occasions, once from the intestinal contents of a small fly caught in the school

kitchen, and once from the surface of a house fly caught in the gas men's room. This organism, which was non-motile, but otherwise like *B. coli in* staining and morphology, produced acid but no gas in glucose and mannite, but did not affect the other sugars. No indol was produced, and milk was made first acid and later alkaline. Gelatin was not liquefied. It therefore corresponds in its cultural reactions with *B. dysenteriæ* (Flexner).

G. S. Graham-Smith.

---

4. The part played by *Musca domestica* and allied (Non-biting) Flies in the spread of Infective Diseases. A Summary of our present knowledge. By George H. F. Nuttall, M.D., F.R.S., Quick Professor of Biology, in the University of Cambridge, and F. P. Jepson, B.A., Student in Medical Entomology, Cambridge.

CONTENTS.

INTRODUCTION.

In the following summary we purposely confine ourselves to those diseases which may be conveyed by *non-biting flies* similar to *Musca domestica*. In compiling the literature we took the monograph by Nuttall (1899) as a basis and have added thereto so as to bring the literature up to date. For convenience sake the diseases referred to have been arranged alphabetically. We have not entered into the subjects of parasitism due to flies or their larvæ (Myaisis), which is relatively rare in this country, nor have we considered the subject of the injury brought about by flies by hastening the decomposition of foods which they contaminate.

We append a bibliography which we have made as full as possible, hoping that it will prove useful to those who are engaged in the study of the fly problem. A number of papers cited in the bibliography are not mentioned in the text. These papers contain no original matter, or are semi-popular in character, or they do not bear directly upon the subject in hand. In the last case a brief note regarding the contents of the papers (fly-biology, myaisis, &c.) accompanies the reference.

The belief that flies may serve to disseminate infective diseases is an old one. MERCURIALIS (1577) considered that they carried the virus of plague from those ill or dead of plague to the food of the healthy. SYDENHAM (1666) remarked that if swarms of insects, especially house-flies, were abundant in summer, the succeeding autumn was unhealthy. A number of authors, *e.g.*, CRAWFORD (1808), might be cited who refer in a general way to insects, especially to house-flies, as carriers of infection; MOORE (1853) refers to flies as possible carriers of cholera, typhoid, tuberculosis, anthrax and leprosy; LEIDY (1872) refers to flies as carriers of the infection of hospital gangrene and of wound infection; COBBOLD (1879), GRASSI (1883), COPLIN (1899), PARKE (1902), MARTINI (1904), BERGEY (1907), HEWITT (1907), SCOTT (1909),* may also be mentioned; but none of these authors do more than offer surmises regarding the part played by flies in the spread of disease.

ANTHRAX.

The earliest experiments with anthrax in relation to flies are those of RAIMBERT (1869) who placed "house-flies" and "meat-flies" on infected material and afterwards tore off their appendages and inoculated them, with positive results, into animals. DAVAINE (1870) made similar experiments with *Musca vomitoria*, and with a like result. CELLI (1888) is responsible for the statement that anthrax bacilli pass, unimpaired in virulence, through the alimentary tract of flies, but it is not clear that he excluded the possibility of there being anthrax spores present in the material upon which he fed his flies. SANGREE (1899) allowed a wingless fly to walk over a plate culture of anthrax and afterwards upon a sterile agar surface; anthrax colonies subsequently developed upon the agar. BUCHANAN (1907) placed a *M. vomitoria* beneath a bell-jar containing a skinned and gutted guinea-pig which had died of anthrax. After being in contact with the carcase the fly was allowed to walk upon agar in two Petri dishes; anthrax colonies developed in both dishes. Three *M. domestica* infected similarly upon anthracic meat, seized in a market, also yielded anthrax colonies.

These experiments made by successive observers, apparently in ignorance of their predecessors' work, all agree in demonstrating that flies pick up anthrax bacilli when they walk about and feed on infected material. It remains to be determined how long flies may harbour the bacillus or its spores, and whether the virulence of the bacillus in the vegetative stage is modified by passage through the

* Cited in the Bibliography.

intestines of flies. As JOSEPH (1887) and NUTTALL (1899) have suggested, it appears probable that non-biting flies may, when infected, spread anthrax by depositing the bacilli upon wounds or food. Actual experiments in this direction appear to be lacking.

CHOLERA.

MOORE (1853) drew attention to the necessity of guarding food against flies, because, he supposed, they might disseminate cholera, adding: "flies in the East have not far to pass from diseased evacuations or from articles stained with such excreta, to food, cooked and uncooked." NICHOLAS (1873) writes that in 1849, when cholera prevailed at Malta: "My first impression of the possibility of the transfer of the disease by flies was derived from the observation of the manner in which these voracious creatures, present in great numbers, and having equal access to the dejections and food of the patients, gorged themselves indiscriminately and then disgorged themselves on the food and drinking utensils. In 1850 the 'Superb,' in common with the rest of the Mediterranean squadron, was at sea for nearly six months; during the greater part of the time she had cholera on board. On putting to sea the flies were in great force; but after a time the flies gradually disappeared, and the epidemic slowly subsided. On going into Malta harbour, but without communicating with the shore, the flies returned in greater force, and the cholera also with increased violence. After more cruising at sea, the flies disappeared gradually with the subsidence of the disease." FLÜGGE (1886, pp. 359, 370) expresses his belief that insects (flies) may infect the food in cholera times. Their numbers vary extraordinarily at times and in certain places. They must play an important part, especially when they are numerous. "A quantitative determination of this influence is, of course, impossible." Flügge also draws attention to the fact that the worst cholera months are those in which insects abound. TSUZUKI (1904, p. 77), of the Japanese Army Medical Service, reporting upon the cholera epidemic in North China in 1902, writes that "flies in China are a terrible infliction to the stranger," and if flies are capable of carrying about the cholera germ they must play an important part in the spread of the disease (*see* his experiments on p. 17; they gave a positive result).

Experiments.

The first recorded experiments on flies in relation to cholera are those of MADDOX (1885), in which *Musca vomitoria* and *Eristalis tenax*, &c., were fed on impure and pure cultures of the cholera vibrio, which were added to sugar. Maddox was evidently not accustomed to bacteriological methods, for he gives a lengthy but unsatisfactory account of his experiments, which do not seem to have attracted any particular attention. He, however, does seem to have determined microscopically the presence of motile cholera vibrios in the dejections of the insects, and, from his observations, concludes that they serve as agents in the spread of cholera.

The first to make accurate experimental observations on the part played by flies in the spread of cholera were TIZZONI and CATTANI

(1886) in Bologna. In two out of three experiments made with flies caught in the cholera wards and put aside for some hours, the cultures showed characteristic cholera colonies. SAWTCHENKO (1892) fed flies with bouillon cultures of cholera and found the vibrios in the flies' dejections after a period of two hours, of course in impure culture. When the flies had fed for some time on cholera culture almost no other bacteria could be isolated from their dejections. He gained the impression that the vibrios multiplied in the fly's body. Previous to making cultures from the flies Sawtchenko disinfected them outwardly by placing them in alcohol and afterwards in 5 per cent. carbolic acid solution; they were dried on filter paper and then cut open.

SIMMONDS (1892), working at the Old General Hospital in Hamburg, studied the flies which were present in the post-mortem room, where many bodies and intestines of persons dead of cholera were lying about. Catching a fly, he was able to isolate cholera vibrios from it in large numbers. Thinking the many flies present might be a source of danger, he caused the corpses to be sewed up, and the autopsy tables to be washed off as promptly as possible, with the result that vibrios could no longer be obtained from the flies in the room. As the vibrios would eventually die from drying when attached to the outer surface of flies that are flying about, Simmonds tried to determine how long they would remain alive in this situation. For this purpose he placed flies on a fresh cholera intestine, and then transferred them singly to large flasks in which they could fly and move about freely. Roll cultures made at various intervals of time (five to 45 minutes) all gave positive results. In a second experiment six flies were placed in a bell-jar with cholera intestine, and then removed to a large flask, where they remained flying and creeping about for an hour and a half. Cultures made from these flies yielded innumerable colonies. Simmonds concluded that flies may play a serious part in spreading the infection, and, as a practical outcome of his experiments, laid stress on the necessity of covering cholera dejections until disinfected, and of protecting food from flies.

UFFELMANN (1892) allowed two flies to feed on liquefied gelatine cultures of cholera, and after they had been kept an hour and two hours respectively in a glass, he made roll cultures with them. The first yielded 10,500, the second only 25 colonies. He placed a fly, similarly infected with cholera, in a glass containing sterilized milk which he allowed it to drink. As soon as the fly had finished drinking, he shook the milk, to distribute any organisms which the fly might have introduced, and then placed the milk at 20–21° C. for 16 hours. After this time had elapsed he made cultures from the milk, and found that one drop of milk yielded 100 cholera colonies. A similar experiment, wherein an infected fly was placed on meat, gave a like result. FLÜGGE (1893), citing the experiments of Sawtchenko and Uffelmann, draws attention to the danger from flies, particularly in small households where there is no adequate separation between the cholera patient and the kitchen or place where food is kept. Especially in the latter part of summer and autumn the flies simply swarm in such dwellings, and they may play an important part in spreading the infection.

Special interest attaches to the following observations by Macrae and Buchanan in India. Macrae (1894), aided by Haffkine and Simpson, exposed boiled milk in different parts of the jail at Gaya where cholera and flies prevailed. A high wall separated the male from the female department, and this appears to have cut off the possibility of fly infection, for no cases of cholera occurred on the female side. The milk exposed on the male side became infected with the cholera germ, and it is certain that flies were the agents. Even the milk placed in the cow-shed and cow-shed latrines became infected, though there were no cases of cholera in that portion of the jail. The flies swarmed at Gaya in spite of disinfectants, and settled in great numbers on the cholera stools ; thence they gained access to the rice and milk. Macrae considers that the agency of flies will at times explain the erratic behaviour of cholera, and that it " should be considered as one of the most important agencies in the diffusion of the disease." Buchanan (1897) describes a jail epidemic which occurred at Burdwan in June, 1896. There were great swarms of flies that year. Outside of the prison were some huts where cholera prevailed. A strong wind blew quantities of flies from the side where these huts lay, into the prison enclosure, where they settled on the food of the prisoners. *Only those prisoners who were fed at the jail enclosure nearest the huts acquired cholera*, whilst all the others remained healthy. Though Buchanan's observation was not experimental, it deserves particular attention, and naturally takes its place immediately after a description of Macrae's experiments.

Tsuzuki (1904, p. 77) captured flies in a cholera house in Tientsin, incubated them in bouillon and made plate cultures subsequently from the bouillon. He succeeded in this way in isolating the cholera vibrios from the flies. He also carried out a laboratory experiment by placing 10 flies in a cage with a cholera culture and a Petri dish containing sterile agar ; this experiment also gave a positive result since cholera colonies developed upon the agar. Tsuzuki therefore concludes that flies are capable of conveying the vibrios under natural conditions.

Chantemesse (1905) isolated cholera vibrios from the feet of flies 17 hours after they had been contaminated ; the conditions under which the experiments were carried out are not stated. He considers that flies play an important part in the spread of cholera.

Ganon (1908) stated that flies can transmit infection for at least twenty-four hours after a meal of infective material, and during such a period flies may be carried very long distances in railway carriages. The author was unable to show that the insects could retain the power of infecting for more than four days, as none of those he experimented with lived longer than that period.

The various experiments referred to above, perhaps gain in value from the fact that investigators seem to have been, to a large extent, ignorant of the work done by others. Only Uffelmann refers to any other author, *i.e.*, to Simmonds. We may add that a number of authors, without however contributing any personal evidence on the subject, express their conviction that *M. domestica* disseminates cholera. (*See* Marpmann, 1897 ; Geddings, 1903, etc.).

The body of evidence here presented as to the part played by flies in the dissemination of cholera appears to us quite convincing.*

DIARRHŒA IN INFANTS.

The relation of flies to the spread of summer diarrhœa has aroused special interest of recent years. Fraser (1902), referring to epidemic diarrhœa in Portsmouth, states that "on visiting the houses in question I find that in all, almost without exception, the occupants have suffered from a perfect plague of flies. They told me every article of food is covered at once with flies." . . . . "I repeat that to this, and this alone, I attribute the diarrhœa in the Goldsmith Avenue district."

Nash (1903, p. 128) pointed out that there were 23 cases of the disease in Southend-on-Sea in 1901, whilst there were none in the summer of 1902. *M. domestica* was completely absent in the wet summer of 1902, but appeared in September of the same year; coincident therewith there occurred 13 cases of infantile diarrhœa. Nash (1904) considers that *M. domestica* is the chief carrier of diarrhœa-causing bacteria.

Newsholme (1903, p. 21) has expressed the opinion that food in the houses of the poor can scarcely escape fæcal infection. "The sugar used in sweetening milk is often black with flies, which may have come from a neighbouring dust-bin or manure heap, or from the liquid stools of a diarrhœal patient in a neighbouring house. Flies have to be picked out of the half-empty can of condensed milk before its remaining contents can be used for the next meal." Newsholme considers the greater prevalence of diarrhœa among infants fed on Nestlé's milk as due to the fact that flies are more attracted to it than to ordinary cow's milk because of its sweetness.

Copeman (1906, p. 18) in a report to the Local Government Board dealing with endemic prevalence of infantile diarrhœa at Wigan says:—"At the Miry Lane Depôt there is always stored (awaiting removal by farmers) an enormous amount of nightsoil mixed with ashes which, in hot weather especially, is not only exceedingly offensive, but is beset by myriads of house-flies. As the result of personal enquiry at the various houses in the neighbourhood in which, during the year 1905, deaths from diarrhœa had occurred, I learnt that considerable nuisance from the foul odours was apt to be experienced during the prevalence of hot weather, especially with the wind in the south or south-west, *i.e.*, blowing from the Depôt to the special area, so much so on occasions as to render it necessary to shut all the windows, while the inhabitants of houses

* Sibthorpe (1896) claimed that the flies fulfil the office of scavengers, destroying rather than conveying the poison of cholera. He relates that an outbreak of cholera occurred in a native regiment in India under his command. On each occasion of their leaving and occupying a new camp, a recrudescence of the disease occurred. He attributes this to the flies having been left behind. Francis (1893) cites the case of a woman he saw at Nusserabad in 1846, who developed cholera a few minutes after swallowing a fly and died the same evening. The title of this communication reads (!) "Cholera caused by a fly?"

nearest the Corporation Depôt stated that at certain times of the year their rooms were apt to be invaded by a veritable plague of flies, which swarmed over everything of an edible nature on the premises. This being so, it would appear not improbable that these flies, some of which have doubtless had opportunity of feeding on and becoming contaminated with excremental material of human origin, may have been a means of carrying infected material to certain foodstuffs, such, more particularly, as milk, and sugar, and so, indirectly, of bringing about infection of the human subject."

Snell (1906) Medical Officer of Health, Coventry, is stated by Ainsworth (1909) to have shown that 70 per cent. of the "cases of infantile diarrhœa occurred in the north-east part of his district, close to a large collection of refuse where flies swarmed."

Sandilands (1906, p. 90) considers that there are "good grounds for the supposition that in this disease, which in some respects is analogous to typhoid fever and cholera, flies may be carrying agents of the first importance." He notes that the meteorological conditions which influence the prevalence of diarrhœa "exercise a precisely similar effect upon the prevalence of flies."

"The immunity of well-to-do infants may be explained, partly by the distance that separates the sick from the healthy, and partly by the small number of flies in their neighbourhood. In poorer districts six or seven babies may occupy the tenements of one house with a common yard where the flies congregate and flit in and out of the open windows, themselves conveying infected excrement to the milk of healthy infants, or depositing the excrement in the dust-bin, whence it may again be conveyed into the house by other flies. Calm weather promotes diarrhœa, and high winds are unfavourable to the spread of diarrhœa and to the active migration of flies alike. Loose soil and fissured rock, containing organic filth in its crevices, favour the spread of diarrhœa and the breeding of flies, whilst solid rock is unfavourable to both." (*See* also Newsholme, 1906, p. 145.)

Hamer (1908), who has studied the relation of fly prevalence (*Musca*, *Homalomyia*) to diarrhœa from an epidemiological point of view, appears to be somewhat sceptical as to flies being active agents in the spread of infection. He considers that the increase in flies and diarrhœa may be due simply to a coincidence.

Ainsworth (1909, p. 498) has studied the relation of infantile diarrhœa to flies in Poona and Kirkee, India, and illustrates the relation by means of a yearly curve which is very striking as affording evidence that flies stand in causal relationship to diarrhœa. (His method of observation is referred to on p. 26 in connection with typhoid fever.)

All authorities agree that flies rest under strong suspicion of serving as disseminators of diarrhœal infection.

DIPHTHERIA.

With regard to the dissemination of *B. diphtheriæ* by flies we find only one reference: Smith (1898; cited by Dickinson, 1907) tried the oft-repeated type of experiment by allowing house-flies to walk over infected material and then over sterile media. Naturally,

he obtained a positive result. There is no evidence that under natural conditions flies have anything to do with the spread of diphtheria, but it is, of course, conceivable that they may convey the infection under suitable conditions.

DYSENTERY.

We have no direct evidence bearing upon flies in relation to dysentery. Smith (1903) writes: "An old idea of some Anglo-Indian surgeons was that dysentery could be caught by using the same latrine as a dysentery patient. There may be something in this . . . . . the ubiquitous fly may, therefore, be a dysentery inoculator in open camp latrines." Bergey (1907) also considers that flies may disseminate dysentery as they do cholera and typhoid.

FRAMBŒSIA TROPICA (YAWS).

Wilson (1868, p. 466) says the belief prevails in the West Indies that the disease is conveyed from one individual to another by flies. Hirsch (1896) reports two cases in which he thinks the disease was conveyed by flies. Both patients were living among Fijian children who had the disease. One patient had an uncovered ulcer, the other sores on his feet; "thus each had raw surfaces which could be inoculated by the poison," and would naturally be sought by flies. Cadet (1897) says that lesions of the skin (ulcers, insect or leech-bites, scratches, &c.) are necessary for infection to take place. This may occur through direct contact, through infected clothes or flies, the latter transporting the virus on their feet which are soiled with diseased secretions.

Experiments.

Castellani (1907, pp. 567–568) tested the matter of the fly-transmission of Yaws by experimental methods. He allowed *M. domestica* to feed (1) upon yaws material (scraping from slightly ulcerated papules), and (2) upon semi-ulcerated papules on the skin of three yaws patients. In both cases he was able to discover the *Spirochæta pertenuis* in microscopic preparations made from the flies' mouth-parts and legs. Furthermore, he allowed *M. domestica* to feed on yaws material (1 and 2 as above) and afterwards transferred them to scarified areas upon the eye-brows of monkeys. Of 15 monkeys thus experimented upon three developed yaws papules at the places which had been contaminated by the flies. Castellani concludes that "Yaws is generally conveyed by actual contact, but under certain circumstances it may be conveyed by flies and possibly by other insects."

OPHTHALMIA.

The part played by non-biting flies in the spread of Ophthalmia is well recognised to-day. Budd, as early as 1862, considered it was fully proven that flies serve as carriers of Egyptian ophthalmia; Laveran (1880), writing of Biskra, says the same. Howe (1888, p. 323; cited by Abel, 1899), stated that (1) the number of cases increases rapidly from the moment when flies are present in large

numbers; (2) Eye trouble occurs in the same places where flies are numerous (Delta of the Nile); where there are a few flies (The Desert) there are also few cases of illness; (3) Natives and especially children are remarkably indifferent to the attacks of flies, they allow the flies to settle in crowds about their eyes, sucking the secretions, and never think of driving them away; (4) Examination of the flies captured on diseased eyes revealed bacteria on their feet which were similar to those found in the conjunctival secretion. Other authors are quite in agreement with Howe in this matter (see FUCHS, 1894, p. 211).

That gonorrhœal and other infections of the eye may be caused by flies is generally agreed (BRAUN, 1882; DEMETRIADES, 1894; GERMAN, 1896). WELANDER (1896) observed an interesting case wherein an old bedridden woman in a hospital became infected. This patient's bed was alongside of that of another patient who had blennorrhœa, but a screen, which did not reach to the ceiling, separated the beds. All means of infection, except through the agency of flies, appeared to be excluded. Wellander found that flies bore living Gonococci upon their feet three hours after they had been soiled with secretion, for they infected ascites-agar plates with which they came in contact.

The evidence regarding the spread of Egyptian ophthalmia by flies appears to be conclusive, and the possibility of gonorrhœal secretions being conveyed by flies cannot be denied.

PLAGUE.

Although it cannot be claimed to-day that house flies play a part of any moment in the spread of plague it is a matter of some interest to note what has been recorded on the subject. Older writers like BISHOP KNUD (1498) and VARWICH (1577) note the occurrence of flies in large numbers in plague times. MERCURIALIS (1577) definitely referred to house-flies as carriers of the plague from the fact that they contaminated food upon which they settled after abandoning plague patients. LANGE (1791) also regarded flies as carriers "humoribus pestiferorum" from the dead to the living. HAESER (1882) refers to Bengasi, Tripolis, in connection with a plague epidemic, in 1858, as being known to the Turks by the name of the "Kingdom of Flies."

Turning to more recent times it may be noted that YERSIN (1894) in Hong Kong observed many dead flies lying about in his laboratory when he made autopsies on plague animals. He demonstrated by inoculation into animals that a dead fly contained virulent plague bacilli. NUTTALL (1897), experimenting with *M. domestica* fed them on organs of animals dead of plague. He found that flies might survive eight days at 12–14°C. after feeding on infected organs and that they still harboured virulent bacilli 48 hours or more after they were transferred to clean vessels. At higher temperatures, 14°C. and upwards, the infected flies died more rapidly than did control flies which were fed on the organs of healthy animals. Nuttall concluded that the plague bacillus may be fatal to house-flies under suitable conditions of temperature. MATIGNON (1898, p. 237) observed that flies died in large numbers in Mongolia during plague times.

SMALLPOX.

We have found but one reference to flies in relation to smallpox. HERVIEUX (1904) states that LAFORGUE at Tamorna-Djedida, Province of Constantine, observed the following during an epidemic at the above-mentioned place. The children who were attacked all lived in the south-west of the village; the northern part of the village remained free from smallpox. This distribution was attributed to the direction of the prevailing winds and it was noted that flies and mosquitoes were distributed with the wind. Laforgue believed that flies played an important part in spreading the virus of smallpox.

STAPHYLOCOCCUS PYOGENES AUREUS.

Three observers appear to have experimented with pyogenic bacteria; CELLI (1888) reported experiments of Alessi's, which were doubtless conducted with *M. domestica*. He states that the staphylococci passed through the flies' alimentary canal without loss of virulence.

JOLY (1898) isolated staphylococci from a house-fly caught in a clinical laboratory.

BUCHANAN (1907, p. 217) allowed *M. domestica* to walk across a pus-soiled surface, and afterwards on agar upon which colonies of staphylococci subsequently developed.

SWINE FEVER.

BUCHANAN (1907, p. 217) caught *Musca vomitoria* upon carcases of pigs which had died of swine fever, and which had been subjected to post-mortem examination. The captured flies were allowed to walk across media contained in Petri dishes, and the swine fever bacillus was recovered from one of the cultures.

TROPICAL SORE.

That flies convey "Bouton de Biskra," is asserted by SERIZIAT (1875) and by LAVERAN (1880). TSCHEREPKIN (1876) who described a similar affection as occurring at Taschkent, states that the disease in that locality is attributed to the bite of certain insects, whence its name, "Päschä-Chûrdj," meaning "fly-bite." SERIZIAT asserts that a lesion of the skin is always necessary for infection to take place, and that the affection unquestionably results at times in consequence of a mosquito bite. Laveran says that from September to October inclusive (at Biskra), the slightest wound tends to become transformed into the bouton. He has seen it "graft itself, so to speak, on pustules of acne or impetigo, on wounds following burns or the application of vesicatories, finally on vaccine pustules." FLEMING (Brit. Army Med. Rep. for 1868, X, and 1869, XI), WEBER (Rec. Mém. Méd. Mil., 1876), and MURRAY (Brit. Med. Journ., 1883) proved that the disease was inoculable from man to man. Laveran states that it spreads by scratching in an individual affected. He does not doubt that flies carry the virus on their feet and proboscides and thus give rise to infection.

More recent observation does not appear to have thrown further light on the subject.

TUBERCULOSIS.

The first to investigate *M. domestica* in relation to the possible dissemination of the tubercle bacillus were Spillman and Haushalter (1887). These authors found tubercle bacilli in the intestinal contents and dejections of flies which had fed on tubercular sputum. Hofmann (1888) carried out observations under natural conditions by examining flies captured in the room of a phthisical patient. He found tubercle bacilli in four out of six flies examined, and also in the excreta of flies scraped from the walls, door, and furniture of the room. Celli (1888) has reported experiments by Alessi in which the latter fed flies upon tubercular sputum, and subsequently inoculated the flies' dejections into rabbits, thus causing the latter to become tuberculous.

Hayward (1904, p. 643) fed *M. domestica* (and blue-bottles) on tubercular sputum, and allowed the flies to walk and deposit excrement on clean coverglasses. Flies caught whilst feeding on tubercular sputum that had been placed in bottles for examination in the laboratory, were similarly tested for tubercle bacilli. *B. tuberculosis* was found on most of the coverglasses. Hayward states that he obtained cultures of tubercle bacilli from the flies' fæces (scarcely an easy task!), and that the fæces produced tuberculosis in guinea-pigs. Flies fed on the sputum died after two to three days, whilst control flies fed on milk lived eight to ten days in confinement. According to Lord (1904) virulent tubercle bacilli may be given off in the excreta of flies which have fed on tubercular sputum.

Buchanan (1907) allowed *M. domestica* to walk across a surface soiled with tubercular sputum, and afterwards across a surface of clean agar. The agar was washed, and the washings were inoculated into a guinea-pig. The guinea-pig died of tuberculosis 36 days after inoculation.

Without doubt, then, flies are capable of disseminating the tubercle bacillus. Cobb (1905) believes that they may play a part of some importance by infecting human food to which they may gain access after feeding on tubercular sputum. Mays (1905) characterises Cobb's views as "unequivocal rubbish," a somewhat dogmatic assertion.

TYPHOID FEVER.

(1) *Circumstantial Evidence that Flies act as Carriers.*

Some valuable evidence has accumulated during the last decade upon flies in relation to typhoid fever, more especially as occurring in camps.

American Army.

Veeder (1898), writing of flies as spreaders of disease in American camps, says that he once saw typhoid dejections emptied from a commode, and the latter, without being disinfected, placed near a pitcher of milk which had just been left at the door. This occurred in an otherwise cleanly household. Flies gathered about the milk and the commode and may have flown from one to the other. Veeder asks: "Is it strange that there were numerous cases of the

disease in that house and others in the house next to it?" He had recently observed the behaviour of flies in a military camp and "seen fæcal matter in shallow trenches open to the air, with the merest apology for disinfection, and only lightly covered with earth at intervals of a day or two. In sultry weather this material, fresh from the bowel and in its most dangerous condition, was covered by myriads of flies, and at a short distance there was a tent, equally open to the air, for dining and cooking (!). To say that the flies were busy travelling back and forth between these two places is putting it mildly." (He states he made cultures from the fly-tracks and excrements but does not say what organisms he found.) He concludes that the conveyance of typhoid infection "in the manner indicated is the chief factor in decimating the army." He very rightly adds: "Certainly, as far as it is known to the writer, nothing adequate has been said about it in current discussions." On the other hand, the water supply has constantly been blamed.

Chmelicek (1899, p. 193), writing of his observations on typhoid epidemics in southern camps at the time of the Spanish-American war, states of the camp at Tampa, Florida: "The pits were only about forty feet from the entrance to the kitchen tent, and the number of flies around these holes was countless." The largest number of cases of typhoid occurred amongst cavalrymen, a fact which the author (p. 196) attributes to "the numberless flies that gather around horses," the flies flying about from the pits to the kitchen where the brown sugar "exposed for hours was almost black with them, looking more like a bag or box full of rasins than sugar." . . . . . "It was impossible to keep the flies from the already cooked food, even if a man kept one hand over it and ate it with the other."

The directions of Surgeon-General Sternberg, U.S.A. (25, IV. 1898, Circular No. 1) were explicit enough to guard against the camp conditions described above and they definitely state that flies are probably carriers of typhoid since "they swarm about fæcal matter and filth of all kinds deposited upon the ground or in shallow pits and directly convey infectious material attached to their feet or contained in their excreta to the food which is exposed . . . ."

Walter Reed, Surgeon in the U.S. Army, reported that the typhoid epidemic in camps in Cuba was certainly due to food contaminated by flies "the conditions being especially favourable for this manner of dissemination."

Victor Vaughan, member of the U.S. Army Typhoid Commission, in 1900, came to the following conclusion, believing that flies were active in the dissemination of typhoid fever:—

"(*a*) Flies swarmed over infected fæcal matter in the pits, and then visited and fed upon the food prepared for the soldiers at the mess tents. Where lime had been recently sprinkled over the contents of the pits, flies with their feet whitened with lime, were seen walking over the food.

(*b*) Officers, whose mess tents were protected by means of screens, suffered proportionately less from typhoid fever than did those whose tents were not so protected.

(*c*) Typhoid fever gradually disappeared in the fall of 1898 with the approach of cold weather and the consequent disabling of the fly."

"It is possible for the fly to carry the typhoid bacillus in two ways. In the first place, fæcal matter containing the typhoid germ may adhere to the fly and be mechanically transported. In the second place, it is possible that the typhoid bacillus may be carried in the digestive organs of the fly and may be deposited with its excrement." (Quoted by HOWARD, 1905.)

Boer Prisoners in Ceylon.

QUILL (1900) records of the Diyatalawa Camp, Ceylon, in 1900, where typhoid fever occurred among Boer prisoners: "During the whole period that enteric fever was rife in the Boer camp, flies in that camp amounted almost to a plague, the military camp being similarly infested, though to a lesser extent."

British Army.

TOOTH and CALVERLEY (1901, p. 73), writing of typhoid in camps during the South African war, state that "In a tent full of men, all apparently equally ill, one may almost pick out the enteric cases by the masses of flies that they attract. This was very noticeable at Modder River, for at that time there were in many tents men with severe sunstroke who resembled in some ways enteric patients, and it was remarkable to see how the flies passed over them to hover round and settle on the enterics. The moment an enteric patient put out his tongue one or more flies would settle on it."

The authors further state that: "At Bloemfontein the flies were a perfect pest; they were everywhere, and in and on every article of food. It is impossible not to regard them as important factors in the dissemination of enteric fever. Our opinion is further strengthened by the fact that enteric fever in South Africa practically ceases every year with the cold weather, and this was the case at Bloemfontein. For though the days after 10 a.m. were as an English summer day, and the temperature in our tents was rarely below 70° and often about 80°F., the nights are very cold, and often frosty, and with the cold nights the flies disappeared. It seemed to us that the cold weather reduced the number of enteric cases by killing these pests."

SMITH (1903), also writing of South Africa, states that a neglected trench "becomes an open privy with an infected surface soil around it; the flies browse in it in the day-time, and occupy the men's tents at night. On visiting a deserted camp during the recent campaign it was common to find half-a-dozen or so open latrines containing a fetid mass of excreta and maggots. This because the responsible persons so often failed to comply with the regulations for encampments by filling in latrines on the departure of the troops."

AUSTEN (1904, p. 656) vividly recalls "a latrine in a certain standing camp in South Africa during the late war, in which the conditions as regards flies were precisely as described by Major Smith. It is only fair to say that the ground was extremely hard

and stony, so that very little soil was available for covering up the contents of the trench. On visiting this latrine after it had been left undisturbed for a short time, a buzzing swarm of flies would suddenly arise from it with a noise faintly suggestive of the bursting of a percussion shrapnel shell. The latrine was certainly not more than one hundred yards from the nearest tents, if so much, and at meal times men's mess tins, &c., were always invaded by flies. A tin of jam incautiously left open for a few minutes became a seething mass of flies (chiefly *Pycnosoma chloropyga* Wied.), completely covering the contents."

F. Smith (1903, p. 331) refers to his experience in the South African war in seeing flies go from bed-pans to milk, &c., and discusses in detail methods of sewage disposal in warm countries.

Straton (1907, p. 224), writing of Meerut, India, and the seasonal incidence of typhoid there, says that typhoid "recurs after the rains are over, when the dust and flies reappear." There is a great diminution of typhoid during the monsoon. He describes methods of dealing with latrines.

Jones (1907, p. 22), writing of his experience in the Army at Nasirabad, India, says: "We have been led in this station to regard fly infection as the principal cause of the unenviable prevalence of enteric fever." His paper concludes with various recommendations including measures to abate the fly nuisance.

Ainsworth (1909) has studied the seasonal incidence of typhoid fever and house-flies in the stations at Poona and Kirkee. He concludes that the result "is highly significant and at least suggests that a *primâ facie* case has been established for further investigations." Flies were present in enormous numbers during the typhoid season and were bred in horse manure. By means of curves he illustrates the rise and fall of the typhoid incidence, the rainfall, and fly prevalence. The estimation of the numbers of flies was made by catching them on sheets of tanglefoot which were changed every 24 hours. The curve given on pages 497 and 498 are certainly very striking, the fly curve reaching its acme about two weeks before the maximum number of cases of typhoid occurred. (See also under Diarrhœa, p. 19.)

Other evidence.

Hamilton (1903) states that the typhoid epidemic in Chicago could not be wholly attributed to the defective water supply. She referred it partly to the common house-fly which prevailed in the most severely stricken portions of the city and contaminated the food.

Smith (1904, p. 423), whilst recognizing that flies may play an important part in the spread of typhoid fever in warm countries, believes that the part they play "is probably a relatively small one in the climate of Belfast."

Klein (1908, p. 1150, footnote) refers to an outbreak of typhoid fever studied by Wilshaw. "After the occurrence of a case of enteric fever in a house forming one of a row, a number of typhoid cases making their appearance in the neighbouring houses. All known channels of transmission, for example, personal contact, defective drainage, polluted water or milk, could be excluded. The only

condition common to all the houses of the row was this—that they were swarming with flies." Klein examined some of these flies by crushing them and making cultures from the crushed mass. He obtained *B. typhosus* and *B. coli* from the flies. We assume that the flies were *M. domestica.*

Experiments.

The experimental evidence regarding the part played by flies in typhoid fever is as follows :—

Celli (1888) fed flies with pure cultures of the *Bacillus typhosus* and examined their contents and dejections microscopically and culturally. Inoculations on animals were also made, proving, as he supposed, that the bacilli which passed through flies were virulent. (He made similar observations with the *Spirillum Finkler-Prior.*)

As Ficker (1903, p. 274) properly points out, Celli's statement has less value to-day, since at the time he carried out his experiments no suitable means existed for properly differentiating *B. typhosus* from other organisms of similar character.

Firth and Horrocks (1902) kept *M. domestica* (also bluebottles) in a large box measuring 4 by 3 by 3 feet, with one side made of glass. They were fed on material contaminated with cultures of *B. typhosus.* Agar plates, litmus, glucose broth and a sheet of clean paper were at the same time exposed in the box. After a few days the plates and broth were removed and incubated with a positive result. The flies' excreta on the paper yielded *B. coli* almost in pure culture. In a second experiment some fresh typhoid stool to which a typhoid culture had been added was dusted with earth and served as the infective material ; colonies of *B. typhosus* appeared on the plates. In a third experiment the infected flies were captured and killed. By means of sterile forceps there heads, wings, legs and bodies were separated and respectively placed in sterile broth. Sub-cultures of the broth all gave a positive result. The authors conclude that *M. domestica* can convey *B. typhosus* from infected sources to objects upon which they walk, rest or feed, and that bacilli adhere to the external parts of flies. "It has not been proved that the enteric bacillus passes through the digestive tract of the fly."

Hamilton (II. 1903) in Chicago, caught 18 flies in and about houses and rooms occupied by typhoid cases, and states that she found *B. typhosus* in five of them.

Ficker (1903) caught flies in a house in Leipzig where eight cases of typhoid had occurred. He isolated *B. typhosus* from the flies. He carried out experiments with *M. domestica* kept in 10-litre flasks into which he introduced some sugar, strips of filter paper and culture of typhoid bacilli in bouillon. This was spread on the glass and partly absorbed by the filter paper. After 18 to 24 hours the flies were transferred to clean flasks. He found the flies to survive over four weeks in captivity if protected from the cold and fed on sugar, bread and water, or milk. He notes that flies may all die during a cold night, irrespective of typhoid bacilli being present in their food. The flies were transferred to clean flasks every two to three days. The flies to be examined were etherized and rubbed up in a mortar—the crushed material being used for

making plates on gelatin and special media. *B. typhosus* was recovered from the flies 23 days after they had been infected.

Buchanan (1907) allowed *M. domestica* to walk over the surface of a Petri dish smeared with typhoid dejections. The flies (number ?) were immediately afterwards allowed to walk over the surface of media in Petri dishes Naturally, some plates became infected.

The evidence regarding the part that flies may play in the spread of typhoid fever may therefore be accepted as quite conclusive.

PARASITIC WORMS.

That house-flies may disseminate the eggs of parasitic worms appears sufficiently clear from the following observations by Grassi and Stiles.

Grassi (1883) broke up segments of *Tœnia solium* in water, the same having been preserved some months in alcohol. The flies came and sucked up the eggs with the water. The eggs came away unaltered in the insects' dejections. The same thing was observed to occur with the eggs of *Oxyuris*. Experimenting with unsegmented eggs of *Trichocephalus*, which were placed on the laboratory table at Rovcllasca, he saw the flies feed on them, and, some hours later, found the eggs in the flies' dejections, which had been deposited in the kitchen in the floor beneath, at a distance of 10 metres from the place where the insects had been fed. He placed sheets of white paper in the kitchen on which the flies defecated, and he also caught some flies there whose intestines were full of the eggs. That flies were able to take up corpuscular elements through their proboscides was thus proved. He also fed them on *Lycopodium* spores, *Oïdium lactis* from cream, and the spores of *Botrytis* taken from silkworms. Both *Oïdium* and *Botrytis* were found in the flies' dejections.

Stiles (1889 or 1890, personal communication to Nuttall, 1899) placed the larvæ of *Musca* with female *Ascaris lumbricoides*, which they devoured, together with the eggs they contained. The larvæ, grubs, as also the adult flies, contained the eggs of *Ascaris*. The experiment being made in very hot weather, the Ascaris eggs developed rapidly, and were found in different stages of development in the insects, thus proving that the latter may serve as disseminators of the parasite. Providing that the eggs attain the proper stage of development, the fly, acting simply as a carrier, might convey the parasite to man by falling into or depositing its excreta on the food.

OBSERVATIONS ON THE DISSEMINATION OF NON-PATHOGENIC MICRO-ORGANISMS BY FLIES.

Bacillus prodigiosus.

The observations made upon this bacillus are of interest since, in a mechanical sense, they bear directly upon the dissemination of pathogenic organisms by flies. Bacteriological literature contains frequent references to the occurrence of this bacillus on food. Although the organism is quite harmless it has arrested attention

because it produces blood-red colonies upon the substances on which it grows. The miracle of "the bleeding host" in the middle ages has been attributed by modern writers to the development of *prodigiosus* colonies upon the wafers in damp churches. Because of the characteristic pigment which it produces, *B. prodigiosus* has been a favourite organism in experimental work. Thus, as early as 1875, Otto Helm (cited by Abel, 1899, p. 1,068) experimented with "*Monas prodigiosa*," and stated that the slimy masses containing the bacillus are easily conveyed by flies from one food substance to another.

Hart & Smith (1898) cite an experiment by Burgess in which flies were fed on material containing the bacillus and then allowed to fly into a large room. After a few hours the flies were recaptured, and made to walk over slices of sterilized potato on which colonies of *prodigiosus* subsequently formed. Abel (1899, p. 1,068), quite independently, carried out a similar experiment. He placed cultures of the bacillus and clean potatoes in different parts of a room. To the latter he added some putrid meat so that the odour should attract the flies. After 2–3 days colonies of *prodigiosus* appeared on all the potatoes. This did not occur when the room was rid of flies.

Abel records two instances in which he observed spontaneous *prodigiosus* infection of food in houses where flies were numerous. He collected flies in both houses, and placed the captured flies singly in tubes containing sterile potato. Of the 28 flies captured in one house seven gave a positive culture; of 33 flies captured in the other house three gave a positive culture. Abel justly argues that flies may convey the bacilli of typhoid and cholera in a similar manner.

Scheurlen (1896, p. 17 *et seq.*) cites 16 recorded cases of "prodigiosus outbreaks." In all cases the outbreaks occurred in July, August and September. Abel points out that the outbreaks appear to follow the same rule as typhoid and cholera epidemics.

Musca domestica as a carrier of moulds.

It is upwards of 20 years since one of us (N.) observed that flies may carry moulds upon their bodies; this was seen in a paste pot into which flies had fallen and had died. Colonies of *Pencillium* developed about several of the flies which had become stuck to the paste. More recently, Gayon (1903), has cultivated various species of mould from flies which he captured and dropped into nutrient gelatin.

CONCLUSIONS.

During the decade which has elapsed since the appearance of the monograph by Nuttall, the interest in the subject of the relation of arthropods in the dissemination of disease has grown steadily. Hygienists the world over have learnt to appreciate the importance of insects as disease carriers in consequence, more especially, of the brilliant discoveries relating to the part played by mosquitoes in the propagation of malaria and yellow fever, by fleas in the spread of plague, by biting-flies and ticks in the spread of various human and animal diseases.

Although a perusal of the preceding pages will show that there were some who at a very early date looked upon the common house-fly with suspicion, it is only of recent years that "flies" have come to be regarded as a serious factor in the spread of infective diseases.

The evidence we have sifted and ordered in these pages is obviously very unequal in value, the most important relating to *cholera and typhoid fever*—in both cases the evidence incriminating house-flies, of which *Musca domestica* may be regarded as the type, appears to be quite conclusive, and these agents will have to henceforth receive the serious attention they demand at the hands of sanitary authorities. From a practical point of view it scarcely appears necessary to charge the house-fly with more misdoings, bacteriological tests having shown that they are capable of taking up a number of different pathogenic germs and of transporting them from one place to another. We regard it as certain that they convey cholera and typhoid fever, and we look forward with confidence to the complete demonstration that they convey the causative agents of infantile diarrhœa and of dysentery, always remembering that there are other vehicles, water, milk, &c., by which these diseases may be communicated.

It should be remembered that a fly may cause *relatively gross infection* of any food upon which it alights after having fed upon infective substances be they typhoid, cholera, or diarrhœa stools. Not only is its exterior contaminated, but its intestine is charged with infective material in concentrated form which may be discharged undigested upon fresh food which it seeks. Consequently, the excrement voided by a single fly may contain a greater quantity of the infective agents than, for instance, a sample of infected water. In potential possibilities the droppings of one fly may, in certain circumstances, weigh in the balance as against buckets of water or of milk!

BIBLIOGRAPHY.

Abel, R. (1899). Einige Ergänzungen zu der in No. 5–12 dieser Zeitschrift erschienenen Abhandlung von Nuttall über die Rolle der Insekten bei der Verbreitung von Infektionskrankheiten des Menschen und der Thiere. *Hygienische Rundschau*, Berlin, ix, pp. 1065–1070.

Ainsworth, R. B. (1909). The House-Fly as a Disease Carrier. *Journ. Roy. Army Med. Corps*, XII., 485–498.

Albert, H. (1905). Rôle of insects in transmission of disease. *New York Med. Journ.*, LXXXI, 220–225.

Aldridge, A. R. (1904). The spread of the infection of enteric fever by flies. *Journ. Roy. Army Med. Corps*, III, 649–651.

Aldridge, A. R. (1907). House Flies as Carriers of Enteric Fever Infection, *Journ. Roy. Army Med. Corps*, ix, p. 558.

Anderson (1908). The differentiation of outbreaks of typhoid fever due to infection by water, milk, flies and contacts. *New York Med. Record*, LXXIV, No. 22. (Not consulted.)

Armstrong, H. E. (1908). House-Flies and Disease ; and the Duties of Sanitary Authorities in relation thereto. (Special report by Medical Officer of Health for Newcastle-upon-Tyne.)

Austen, E. E. (1904). The House-Fly and certain allied species as Disseminators of Enteric Fever amongst troops in the field. *Journ. Roy. Army Med. Corps*, II, 651–668, pl. I, II.

Austen, E. E. (1907). Blood-sucking and other Flies concerned in the spread of disease. In Allbutt's *Syst. Med.*, London, II, pt. 2, pp. 169–186.

Austen, E. E. (1909). African blood-sucking flies (other than mosquitoes and tsetse flies.

Aylott, W. R. (1896). Do Flies spread Tuberculosis ? *Virginia Med. Semi-Monthly*, June 26 ; also appeared in *Amer. Monthly Microsc. Journ.* for August. (Cited by Nuttall, 1899.)

Bachmann (24th March, 1898). Ein Fall von lebenden Fliegenlarven im menschlichen Magen. *Deutsche med. Wochenschr.*, Jahrg., XXIV, pp. 193–194. (Dipterous larvæ in human stomach).

Battersby, J. C. (10th August, 1895). Waterborne typhoid. *Brit. Med. Journ.*, II, p. 393.

Bergey, D. H. (1907). The relation of insects to the dissemination of disease. *New York Med. Journ.*, LXXV, 1120–1125. (An address including a brief review of the subject.)

Berry (1892). Conjunctivitis set up by Flies. *Brit. Med. Journ.*, II, 1114. (Cited by Nuttall, 1899 : Two cases of Conjunctivitis, the one following the bite of a fly, the other following two days after a fly had got into a patient's eye. In the latter "inflammation soon became unmistakably diphtherial.")

Billings (1898). *Twentieth Century Practice of Medicine*, XV. (Cited by Dickinson, 1907, as having found anthrax bacilli in the stomachs and intestines of flies collected from the body of an infected steer.)

Blanchard, R. (1890). *Traité de Zoologie Médicale*, Paris, 2 vols. (Cited by Nuttall, 1899, contains nothing original.)

Bouche, P. Fr. (1834). *Naturgeschichte der Insekten* besonders in Hinsicht ihrer ersten Zustände als Larven und Puppen. 216 pp., 10 pls.

Braun (1882). (Ophthalmia.) *Centralb. f. prakt. Augenheilk.*, p. 545 (a review ; cited by Abel, 1899).

Braun, M. (1906). *The Animal Parasites of Man.* London : John Bale, Sons and Danielsson, 453 pp., 294 figs. (Larva of *Musca domestica* figured on p. 436.)

Britton, W. E. (1905–6). The common House-Fly (*M. domestica*) in its relation to the public health. *Yale Med. Journ.*, N. Haven, XII, 750–757. (Inaccessible.)

Buchanan, R. M. (27th July, 1907). The carriage of infection by flies. *Lancet*, II, pp. 216–218, 5 figs.

Buchanan, W. T. (1897). Cholera diffusion and flies. *Indian Med. Gazette*, Calcutta, pp. 86–97. (Cited by Nuttall, 1899.)

Budd, W. (1862). Observations in the Occurrence (hitherto unnoticed) of Malignant Pustule in England. *Lancet*, II, 164-165. (Cited by Nuttall, 1899.)

Cadet, G. (1897). *Le Pian.* Thèse, Bordeaux (cited by Joly, 1898).

Caldwell (1905). *Manual of Military Hygiene*, p. 237 (refers to flies in trenches. Cited by Dickinson, 1907, *re* flies in camps ; also by Stratton, 1907, p. 234).

Cao, G. (1898). Sul passaggio dei micro-organismi attraverso l'intestino di alcuni insetti. Estratto dall' *Ufficiale Sanitario, Rivista d'Igiene e di Medicina pratica*. Anno XI, 98.

Castellani, A. (1907). Experimental Investigations on Framboesia tropica (Yaws). *Journ. of Hyg.*, VII, 558–569, 2 pl., 1 fig.

Cattle, C. H. (14th July, 1906). A case in which large quantities of Dipterous Larvæ were passed per anum. *Brit. Med. Journ.*, II, 77.

Celli, A. (1888). Trasmissibilità dei germi patogeni mediante le dejecione delle mosche. *Bull d. Soc. Lancisiana d. ospedali di Roma*, fasc. I, p. 1.

Chantemesse (1905). (Cholera and Flies.) Report of Meeting of Acad. de Méd., Paris, reviewed in *Med. Record*, LXVIII, 989.

Chmelicek, J. F. (5th August, 1899). My observations on the typhoid fever epidemic in Southern Camps, and its treatment. *New York Med. Journ.*, LXX, 193–198.

Coates, B. H. (1863). Medical Note on the more familiar flies. *Trans. Coll. Phys. Phila.*, N.S., III, 348.

Cobb, J. O. (25th March, 1905). Is the common house-fly a factor in the spread of tuberculosis ? *American Medicine*, IX, 475–477.

Cobbold, T. S. (1879). *Parasites : a Treatise on the Entozoa of Man and Animals, including some account of the Ectozoa*, 508 pp., 85 figs. London.

Cohn, M. (24th March, 1898). Fliegeneier in den Entleerungen eines Säuglings. *Deutsche med. Wochenschr.*, Jahrg., XXIV, 191–193. (Eggs of *M. domestica* in infant's stools. Cites some literature.)

Copeman, S. M. (1906). Report to the Local Government Board on the General Sanitary Circumstances and Administration of the County Borough of Wigan, with especial reference to Infantile Mortality and to endemic prevalence of Enteric Fever and Diarrhœa. (Dissemination of Infantile Diarrhœa by means of flies, p. 18.)

Coplin, W. M. L. (10th June, 1899). The propagation of diseases by means of insects, with special consideration of the common domestic types. *Philadelphia Med. Journ.*, 15 pp. repr.

Craig, C. F. (1899). The rôle of insects in the propagation of disease. *Philadelphia Med. Journ.*, III, 1381.

Crawford, J. (1808–1809). Observations on the seats and causes of disease. *Baltimore Med. and Physical Recorder*, I, pp. 40, 81, 206 ; II, 31. (This Journ. ceased to exist before the paper had completely appeared. Cited by Nuttall, 1899.)

Crichton-Browne, Sir J. (1908). *Liverpool Sanitation*, 1908.

Davaine, C. (1870). Etudes sur la contagion du charbon chez les animaux domestiques. *Bull. de l'acad. de Méd.*, Paris XXXV, 215–235. (Cited by Nuttall, 1899.)

Deaderick, W. H. (Nov., 1908). Notes on intestinal myiasis. *Arch. f. Schiffs- und Tropen-Hygiene*, XII, 726–729. (References to literature.)

Demetriades (1894). (Ophthalmia.) *Centralbl. f. prakt. Augenheilk.*, p. 412. (A review; cited by Abel, 1899.)

Dickinson, G. K. (1907). The house-fly and its connection with disease dissemination. *Medical Record*, LXXI, 134–139.

Donovan, H. L. (1886). Can flies carry Cholera? *Indian Med. Journ.*, XXI, 318. (Nuttall, 1899, remarks "The title is an abstract of the article.")

Farrar, R. (1905). Reports of Medical Inspectors of the Local Government Board, No. 216, p. 9. Discusses possible carriage of infection by flies in connection with an outbreak of Enteric Fever at Denaby Main in the Doncaster Rural District.

Ficker, M. (1903). Typhus und Fliegen. *Arch. f. Hygiene*, XLVI, 274–283.

Firth, R. H., and Horrocks, W. H. (27th Sept., 1902). An inquiry into the influence of soil, fabrics, and flies in the dissemination of enteric infection. *Brit. Med. Journ.*, 20 pp. repr.

Flügge, C. (1891). *Grundriss der Hygiene*, pp. 473 and 532.

Flügge, C. (1893). Die Verbreitungsweise und Verhütung der Cholera auf Grund der neueren epidemiologischen Erfahrungen und experimentellen Forschungen. *Zeitschr. f. Hygiene*, XIV, 165.

Fonssagrives (1870). Les mouches au point de vue de l'hygiène. *Gaz. hebdom. de méd.*, Paris, 2, S., VII., 370–372. (Nothing original. Cited in bibliography by Nuttall, 1899.)

Francis, C. F. (1893). Cholera caused by a Fly (?) *Brit. Med. Journ.*, II, 65.

Franklyn, G. D. (1906). Some observations on the breeding ground of the common house fly, and a description of a species of moth fly. *Indian Med. Gazette*, XLI, 349. (House-flies breeding in night soil in great profusion; species of fly undetermined.)

Fraser (1902). (Epidemic diarrhœa in Portsmouth in relation to flies.) Lengthly quotation from Fraser's Report for 1902, p. 47, given by Hewlett, 1905, p. 505.

Fuchs (1894). (Egyptian Ophthalmia.) *Wien. klin. Wochenschr.*, No. 12, p. 211. (Cited by Abel, 1899.)

Galli-Valerio, B. (1907). Les insectes comme propagateurs de maladies. *Ber. XIV. Int. Congr. Hyg. u. Demogr.*, Berlin.

Ganon (1908). Cholera and flies. *Geneesk, Tijdschr. v. Nederl. Indie*, XLVIII. 2, quoted in *Journ. Tropical Medicine and Hygiene* for May 15th, 1909.

Gayon, J. P. (1903). A note concerning the transmission of Pathogenic Fungus by flies and mosquitoes. *Public Health* (Amer. Publ. H. Assoc.) XXVIII, 116–117.

Geddings, H. D. (1903). Précis on the fly and mosquito as carriers of disease. *Public Health Reports* (U.S.A.), Vol. XVII, No. 35.

German (1896). (Ophthalmia.) *Centralbl. f. prakt. Augenheilk.* Suppl., p. 386. (Cited by Abel, 1899.)

Gleichen and Keller (circa 1760). *Geschichte der gemeinen Stubenfliege.—Histoire de la mouche commune.* (Rare,—bound in one volume; in the possession of Mr. E. E. Austen, Nat. Hist. Museum, London, S.W.)

Grassi, B. (1883). Les méfaits des mouches. *Archiv. ital. de biologie*, IV, 205–208. Also *Gazz. degli. Ospedale*, 1883, p. 467.

Griffith, A. (May, 1908). Life History of House Flies. *Public Health*, p. 122.

Griffith (1907). Description of a house-fly parasite. *Med. Brief*, St. Louis, XXXV, 59–63. (Inaccessible.)

Haeser (1882). *Geschichte der med. u. epidem. Krankh.* 3. Aufl. Vol. III. (Cited re plague and flies by Nuttall, 1899.)

Hamer, W. H. (1908). Nuisance from flies. *Report of Public Health Committee of London County Council*, No. 1138.

Hamer, W. H. (1908). Nuisance from flies. *Report of Public Health Committee of London County Council*, No. 1202.

Hamerton, A. E. (1908). Introduction to methods of study of the morbid histology of disease-carrying insects. *Journ. Roy. Army Med. Corps*, XI, 243–249.

Hamilton (1903). *Brit. Med. Journal*, p. 149. (Isolation of Tubercle bacillus from flies caught in privy.)

Hamilton, A. (28th Feb., 1903). *Journ. Amer. Med. Assoc.* (Cited by Dickinson, 1907.)

Hamilton, A. (1906). The rôle of the house-fly and other insects in the spread of infectious diseases. *Illinois Med. Journ.*, Springfield, IX, 583–587.

Hart and Smith (1898). *Twentieth Century Practice of Medicine*, Vol. XIII. (Cited by Dickinson, 1907.)

Hayward, E. H. (1904). The Fly as a Carrier of Tuberculous Infection. *New York Med. Journ.*, LXXX, 643–644.

Helm, O. (1875). Ueber Monas prodigiosa, &c. *Arch. f. Pharm.*, LIV., 2. (Quotation in Abel, 1899, p. 1068.)

Henschen (1896). (The larvæ of flies as the cause of a chronic pseudomembranous enteritis.) *Wien. klin. Rundschau*, No. 33. (Review in *Amer. Journ. Med. Sci.*, 1897, CXIII, 732. Aurivillius stated to have assigned the larvæ to "a species nearly related to the common house-fly.")

Hervieux (16th June, 1904). [Report on carriage of small-pox by flies, read to the Academy of Medicine, Paris, June 5th, 1904.] *Lancet*, I, 1761.

Hewitt, C. G. (1906). Preliminary account of the life history of the common house-fly. *Memoirs, &c. of Manchester Literary and Philos. Soc.* Session 1906–1907.

Hewitt, C. G. (1907). The structure, development, and bionomics of the house-fly, *Musca domestica*, Linn. *Quart. Journ. Microsc. Sci.*, LI, Part 3.

Hewitt, C. G. (1907). Bionomics of certain Calyptrate Muscidæ and their economic significance, with special reference to flies inhabiting houses. *Journ. Econ. Biology*, II, pt. 3.

Hewitt, C. G. (1908). Biology of house-flies in relation to Public Health. *Journ. Roy. Inst. Publ. Health*, XVI, 596–608.

Hewlett (1903). Insects as carries of disease. *Med. Press & Circ.* Lond., N.S., LXXVI, 439–442.

Hewlett, H. T. (1905). The ætiology of epidemic diarrhœa. *Journ. of Preventive Med.*, XIII, 496–507. (A useful summary.)

Hirsch, C. T. W. (1896). An account of two cases of Coko or Framboesia. *Lancet*, II, 173–175. (Cited by Nuttall, 1899.)

Hofmann, E. (1888). Ueber die Verbreitung der Tuberculose durch Stubenfliegen. *Correspondenzbl. d. ärztl. Kreis- u. Bezirksvereine im Königr. Sachsen.*, XLIV, 130–133.

Houtum, G. van (1901). *Weekblad van het Nederlandsch Tijdschr. v. Geneesk*, No. 9. (Cited by Ficker, 1903, p. 275.)

Howard, L. O. (1898). *U.S. Bureau of Agricult., Division of Entomol.* Bull. No. 10.

Howard, L. O. (28th Dec., 1900). A contribution to the study of the insect fauna of human excrement. (With especial reference to the spread of typhoid fever by flies.) *Proc. Washington Acad. Sci.*, II, 541–604, pls. XXX–XXXI, 38 figs, repr.

Howard, L. O. (1902). House Flies. (The Principal House Insects of the U.S.A. L. O. Howard and C. L. Marlett). *U.S. Dept. of Agricult., Div. of Entomol.* Bull. No. 4. N.S., Rev. Ed., Washington, pp. 43–47.

Howard, L. O. (1905). *U.S. Bureau of Entomology Circular*, No. 371.

Howard, L. O. (1906). House Flies. *U.S. Dept. of Agricult.* Circ. No. 71. Rev. Ed. (Gives figures of various kinds of flies inhabiting houses, and life history of *Musca domestica.* Suggestions for methods of checking their increase and also mentions some natural enemies.)

Howard, L. O. (18th Mar., 1906). Economic Loss to the People of the United States through Insects that carry disease. *U.S. Dept. of Agric., Bur. of Entomol.* Bull. No. 78, pp. 23–36 and 7.

Howe, L. (1888). (Egyptian Ophthalmia.) *7th Internat. Congr. of Ophthalmol., Wiesbaden:* Becker u. Hess., p. 323. (Quotations in Abel, 1899, p. 1069.)

Huber, J. Chr. (1899). *Diptera* (*Musciden und Oestriden*), *Sarcophila*, *Sarcophaga*, *Calliphora*, *Anthomyia*, *Musca*, *Lucilia*, *Teichomyza*, *Compsomyia*, *Hypoderma*, *Dermatobia*, *Ochromyia*. *Bibliogr. d. klin. Entomologie.* (Hexapoden, Acarinen.) Heft 3, 25 pp.

Hunter, W. (1907). Quoted in article on "The Danger of the Common Fly." *Nursing Times*, 28th Sept., p. 842. (During epidemic of Plague in Hong Kong found plague bacilli in alimentary canal of flies that had fed on infected material.)

Jackson, D. D. (1907). Pollution of New York Harbour as a menace to health by the dissemination of diseases through the agency of flies. *Report to Merchants Assoc., New York.*

Jepson, F. P. (1909). The breeding of the common house-fly during the winter months. *Reports to the Local Government Board on Public Health and Medical Subjects*, N.S., No. 5.

Joly, P. R. (1898) *Importance du rôle des insectes dans la transmission des maladies infectieuses et parasitaires. Du formol comme insecticide.* Bordeaux. (Imprimérie du Midi), 90 pp. *Thèse.*

Jones (1906). The common house-fly as the cause of disease. *Maritime Med. News*, Halifax. XVIII, 285–294.

Jones, F. W. C. (January, 1907). Notes on enteric fever prevention in India. *Journ. Roy. Army Med. Corps*, VIII, 22–34.

Joseph, G. (15th August, 1887). Ueber Fliegen als Schädlinge und Parasiten des Menschen. Theil IV, "Myaisis septica." *Deutsche Medicinal-Zeitung*, No. 65, 725–728.

Kelly, H. A. (August, 1901). A historical note upon diptera as carriers of diseases. *Paré-Déclat. Johns Hopkins Hosp. Bull.*, vol. XII, 7 pp., repr.

Klein, E. (October 1908). "Flies" as carriers of the *Bacillus typhosus. Brit. Med. Journ.*, II, 1150–1151.

Knud (Bishop of Aarhus, Denmark; 1498). *De regimine pestilentico.* (Cited by Mansa, 1872–1873.)

Lambotte, U. (1905). Insectes et maladies infectieuses. *Ann. Soc. méd.-chir. de Liège*, XLIV, 371–389.

Lange, M. (1791). *Rudimenta doctrinæ de peste.* 2nd edit., Offenbach, pp. 27–28. (Quotations given by Abel, 1899, p. 1067.)

Langfield, M. (1905). The rôle of insects in the transmission of disease. *Trained Nurse* (&c.), New York, XXXV, 195, 263, 336.

Laveran, A. (1880). Contribution à l'étude du bouton de Biskra. *Ann. de Dermatologie*, 2 S. I, 173–197.

Leidy, J. (1872). Flies as a means of communicating contagious diseases. *Proc. Acad. Nat. Sc. of Philadelphia.* Meeting of 21 Nov., 1871, 297.

Leidy, J. (1904). *Researches in Helminthology and Parasitology.* Smithsonian Miscellaneous Collections, Washington, Part of Vol. XLVI, 281 pp., 28 figs, repr.

Lord, F. T. (15th Dec., 1904). Flies and tuberculosis. *Boston Med. & Surg. Journ.*, CLI, 651–654.

Lubbock, Sir John (1871). The fly in its sanitary aspect. *Lancet*, II, 270. (Reference.)

MacDougall, R. S. (1906). Insects and Arachnids in relation to the spread of disease. *Pharm. Journ.*, Lond., 4 S. XXII, 60.

McFarland, J. (Jan, 1902). Relation of insects to the spread of disease. *Medicine*, VII, 15 pp., 12 figrs., repr.

Macrae, R. (1894). Flies and Cholera Diffusion. *Indian Med. Gaz.*, pp. 407–412.

Maddox, R. L. (1885). Experiments on feeding some insects with the curved or "comma" bacillus, and also with another bacillus (*subtilis?*). *Journ. Roy. Microsc. Soc.*, ser. 2, V, 602–607, 941–952. (Cited by Nuttall, 1899.)

Mansa, F. V. (1872–3). *Bidrag til Folkesygdommenes og Sundhedspleiens Historie i Danmark fra de aeldste Tider till Begyndelsen af det attende Aarhun drede.* Kopenhagen. (*re* Plague and insects, see pp. 126, 212, 312. Cited by Nuttall, 1899.)

Marpmann, G. (1884). Die Verbreitung von Spaltpilzen durch Fliegen. *Arch. f. Hygiene*, II, 560–563.

Martini, E. (1904). Insekten als Krankheitsüberträger. *Moderne ärztliche Bibliothek*, 39 pp., 27 figs. repr.

Mason, C. F. (1904). The spread of disease by insects. *Internat. clin. Phila.*, 14 S. II, 1–24. (Inaccessible.)

Matignon (1898). *Ann. d'Hygiène*, p. 237. (Cited by Abel, 1899, p. 1066.)

Mays, T. J. (26th Aug. 1905). The Fly and Tuberculosis. *New York Med. Journ.*, LXXXII, 437–438. (Sharp critique of the paper by Cobb, 1905 (q.v.), which Mays characterizes as "unequivocal rubbish.")

Mégnin, J. P. (1874). Du transport et de l'inoculation du virus charbonneux et autres par les mouches. *Compt. rend. de l'Acad. des Sci.*, Paris, LXXIX, 1338–1340.

Mégnin, J. P. (1875). Memoire sur la question du transport et de l'inoculation du virus par les mouches. (1 planche.) *Journ. de l'Anat. et de physiol., &c.* Paris, XI, 121–133. Also in *Journ de méd. vétér. mil.*, Paris, XII, 461–675.

Mégnin, P. (1906). *Les insectes buveurs de sang et colporteurs de virus.* Paris: F. R. de Rudeval, 12°, 150 pp.

Mercurialis (1577). *De pestilentia.* Venice (cited by Abel, 1899), p. 1067, from *Rev. d'Hygiène*, 1897, p. 237).

Moore, Sir W. (3rd June, 1893). Diseases probably caused by flies. *Brit. Med. Journ.*, I, 1154; also *Med. Magaz.*, July, 1893.

Munson, E. L. (1901). *The Theory and Practice of Military Hygiene.* London, Ballière, Tindall & Cox. (Passages from p. 683, cited by Austen, 1904, p. 654.)

Nash, J. T. C. (31st Jan., 1903). The etiology of summer diarrhœa. (Letter to Editors: covers the same ground as Nash (1903) which follows.) *Lancet*, I, 330.

Nash, J. T. C. (1903). The seasonal incidence of typhoid fever and of diarrhœa. The seasonal consumption of shellfish . . . and the seasonal prevalence of flies as regards the latter (diarrhœa). *Trans. Epidemiol. Soc., Lond.*, N.S. XXII, 110–138.

Nash, J. T. C. (Feb. 1904). Some points in the prevention of epidemic diarrhœa. *Lancet*, p. 892. (Repeats observations mentioned in previous papers.)

Nash, J. T. C. (Aug., 1909). House-flies as carriers of disease. *Journ. of Hygiene*, IX, pp. 135–163. In press.

Newsholme, A. (1903). *Annual Report on the Health of Brighton for 1903*, p. 21. (Fly infection of milk.)

Newsholme, A. (1906). Domestic infection in relation to epidemic diarrhœa. *Journ. of Hygiene*, VI., 139–148.

Newstead, R. (1906). On the life-history of *Stomoxys calcitrans*, Linn. *Journ. Econ. Biology*, I, 157–166, pl. XII., reprint.

Newstead, R. (1907). *Preliminary Report on the Habits, Life-cycle and Breeding Places of the Common House Fly* (*Musca domestica*, Linn.), as observed in the City of Liverpool, with suggestions as to the best means for checking its increase. Liverpool: C. Tinling & Co., Ltd., 23 pp., 14 figs.

Newstead, R. (1909). *Second Interim Report on the House Fly*, as observed in the City of Liverpool. Liverpool: C. Tinling & Co., Ltd., 4 pp. (Biology, Distribution, Preventive Measures).

Nicholas, G. E. (15th Nov. 1873). The Fly in its Sanitary Aspect. *Lancet*, II, 724.

Niven, T. (1906). Annual Report of Medical Officer of Health for Manchester, p. 262. (Refers to investigation of range of flight of flies.)

Nuttall, G. H. F. (1897). Zur Aufklärung der Rolle, welche Insekten bei der Verbreitung der Pest spielen. Ueber die Empfindlichkeit verschiedener Thiere für dieselbe. *Centralbl. f. Bakteriol.*, XXII, 87–97.

Nuttall, G. H. F. (9th Sep. 1899). The part played by insects, arachnids, and myriapods in the propagation of infective diseases of man and animals. *Brit. Med. Journ.*, 4 pp., repr.

Nuttall, G. H. F. (Oct. 1899). On the rôle of insects, arachnids and myriapods as carriers in the spread of bacterial and parasitic diseases of man and animals. A critical and historical study. *Johns Hopkins Hosp. Reports*, VIII, 154 pp., 2 plates, repr.

Nuttall, G. H. F. (Nov. 1899). The rôle of insects, arachnids, and myriapods in the propagation of infective diseases of man and animals. *Journ. Trop. Med.*, pp. 107–110.

Nuttall, G. H. F. (1899). Die Rolle der Insekten, Arachniden (Ixodes) und Myriapoden als Träger bei der Verbreitung von durch Bakterien und thierische Parasiten verursachten Krankheiten des Menschen und der Thiere. *Hyg. Rundschau*, IX, 72 pp., repr.

Nuttall, G. H. F. (1907). Insects as carriers of disease. Reprint from *Bericht über den XIV. Internationalen Kongress für Hygiene und Demographie, Berlin, 1907.*

Osmund, A. E. (1909). The Fly; an Etiological Factor in Intestinal Diseases. Cincinnati.

Packard (1874). On the transformation of the Common House Fly, &c. *Proc. Boston Soc. Nat. Hist.*, XVII, 136–150.

Parke (1902). *Practical Hygiene.* (Cited by Dickinson, 1907.)

Poore, G. V. (18th May, 1901). Flies and the science of scavenging. *Lancet*, I, 1389–1391.

Quill, R. H. (1900). Report on an outbreak of enteric fever at Diyatalawa Camp, Ceylon, among the 2nd King's Royal Rifles during the period they acted as guard over Boer prisoners of war. *Army Med. Dept. Report for the year 1900*, p. 452, Appendix 4. (Passages quoted by Austen, 1904, p. 655.)

Raimbert, A. (1869). Recherches expérimentales sur la transmission du charbon par les mouches. *Compt. rend. de l'Acad. de Sc.*, Paris, LXIX, 805–812; also (1870) in *Union Méd.* 3 ser. IX, 209, 350, 507, 709. (Cited by Nuttall, 1899.)

Ramirez, R. (1898). The diptera from a hygienic point of view. *Public Health* (Amer. P. Health Assoc.), XXIV, 257–259). (Nothing original.)

Reed, Vaughan and Shakespeare (1899). *Report on the spread of Typhoid Fever in the United States Military Camps during the Spanish-American War of 1898 to the Surgeon-General of the U.S Army*, Washington.

Ryder, J. A. (1896). Cholera and Flies. *Entomol. News*, III, 210. (Extract cited in *U.S. Dept. of Agric., Div. of Entomol.*, 1896, Bull. 5, p. 20. Only refers to possibilities.)

Sandilands, J. E. (1906). Epidemic diarrhœa and the bacterial content of food. *Journ. of Hyg.*, VI, 77–92.

Sangree (21st Jan. 1899). *New York Med. Record*, LV, 88.

Santori, S. (1905). Le mosche domestiche come causa di diffusione delle malattia infettive intestinali. *Il Policlinico* (Sez. pratica). (Not consulted.)

Sawtchenko, J. D. (1892). Le rôle des mouches dans la propagation de l'épidémie cholérique. *Vratch.* (St. Petersburg); rev. in *Annales de l'Institut Pasteur*, VII.

Scheurlen (1896). Geschichtliche und experimentelle Studien über den Prodigiosus. *Arch. f. Hyg.*, XXVI, 16–17.

Scott, J. (March, 1909). The dangerous house-fly. *Indian Public Health*, V, 292–298.

Sedgwick & Winslow (1903). *Memoirs of the American Academy of Arts and Sciences.* (Cited by Dickinson, 1907, as stating that the three great means for the transmission of typhoid fever are fingers, food and flies, and the authors hold the last to be the most important.)

Senator (1890). Ueber lebende Fliegenlarven im Magen und in der Mundhöhle. *Berlin. klin. Wochenschr.*, No. 7. (Larvæ of *M. domestica* in human stomach and mouth cavity.)

Seriziat (1875). *Études sur l'oasis de Biskra.* Paris. (Cited by Hirsch, *Geogr. Pathol.* III, 477, and by Laveran, 1880.)

Sharpe, W. S. (2nd June, 1900). Influence of dust and flies in the contamination of food and the dissemination of disease. *Lancet*, I.

Shipley, A. E. (July, 1905). *Infinite torment of Flies.* Tennyson. Cambridge Univ. Press. (Printed privately.) 23 pp.

Shipley, A. E. (April, 1907). The danger of flies. *Science Progress.*

Sibthorpe, E. H. (1896). Cholera and flies. *Brit. Med. Journ.*, II, 700.

Simmonds, M. (1892). Fliegen und Choleraübertragung. *Deutsche med Wochenschr.*, 931.

Slater, J. W. (1881). On Diptera as spreaders of disease. *Journ. of Science*, London, 3. S., III, 533–539.

Smith, A. J. (1902). Notes upon several larval insects occurring as parasites in man. *Med. News*, LXXXI, 1060, 2 figs.

Smith, F. (1903, *et seq.*). Municipal Sewerage. *Journ. Trop. Med.*, VI, 285–291, 304–308, 330–334, 353–355, 381–383.

Smith, F. (1907). House flies and their ways at Benares. *Journ. Roy. Army Med. Corps*, IX, 150–155. (Notes breeding place

of *M. domestica* (cow and horse dung), *M. entœmiata* (cow, dog, and human excrement), and *Anthomyia tonitrui* (human ordure), species identified by Mr. E. E. Austen.)

Smith, J. L. (1904). An investigation into the conditions affecting the occurrence of typhoid fever in Belfast. *Journ. of Hyg.*, IV, 407–433.

Snell (1906). (Infantile diarrhœa and flies.) Cited by Ainsworth 1909, p. 487 ; no reference.

Speiser, P. (1904). Insekten als Krankheitsüberträger in Dr. O. Krancher's *Entomolog. Jahrg.*, 1904, 7 pp. repr.

Spillman and Haushalter (1887). Dissemination du bacilli de la tuberculose par la mouche. *Compt. rend.*, CV, 352-353.

Stephens, J. W. W. (1905). Transmission of disease by insects. *Bart's. Hosp. Journ.*, XII, 131–134.

Stiles, C. W. (10th May, 1901). Insects as disseminators of disease. *Virginia Med. Semi-Monthly* (formerly *Virginia Med. Monthly*), VI, 53–58, reprint.

Stratton, C. H. (1907). The prevention of enteric fever in India. *Journ. Roy. Army Med. Corps*, VIII, 224.

Sydenham, T. (1666). *Sydenham's Works*, Syd. Soc. Ed., Vol. I, p. 271.

Taschenberg, E. L. (1880). Praktische Insektenkunde. Vol. IV, pp. 133–134. (Mentions the occurrence of larvæ of *Homalomyia canicularis* in water-closets.)

Taylor, T. (1883). *Musca domestica* a carrier of contagion. *Proc. Am. Assoc. Adv. Sci.*, XXXI, 528.

Thébault, V. (1901). Hémorrhagie intestinale et affection typhoïde causée par des larves de Diptère. *Arch. d. Parasitol.*, IV, 353.

Theobald, F. V. (1904). Swarms of flies bred in house refuse. Second report on Economic Zoology, Part II. *Report on Agricultural Zoology to Board of Agriculture*, pp. 125–126.

Theobald, F. V. (1905). Flies in distribution of disease. *Nursing Times*, London. I, 461.

Thomas, F. G., and Parsons, J. (1908). A case of dipterous larva in the anterior chamber of the eye. Ophthalmological Society, October 15th. Abstract in *Lancet*, October 24, 1908.

Tizzoni, G., and Cattani, J. (1886). Untersuchungen über Cholera. *Centralbl. f. d. med. Wissensch.* Berlin, 769–771.

Tooth, H. H., and Calverley, J. E. G. (1901). In "*A Civilian War Hospital*, being an account of the work of the Portland Hospital, &c. in S. Africa, by the Professional Staff." London : John Murray. (Passages quoted by Austen, 1904, p. 655.)

Tscherepkin (1876). *Petersburg. med. Wochenschr.*, No. 2. (Cited by Hirsch, *Geogr. Pathol.*, III, 477.)

Tsuzuki, J. (1904). Bericht über meine epidemiologischen Beobachtungen und Forschungen während der Choleraepidemie in Nordchina im Jahre 1902, &c. *Arch. f. Schiffs- u. Tropen-Hyg.*, VIII, 71–81.

Uffelmann, J. (1892). Beiträge zur Biologie des Cholerabacillus. *Berlin. klin. Wochenschr.*, 1213–1214.

Underwood, W. L. (1903). *House-fly as carrier of disease.* Boston. 8°. (Cited in *Index Medicus*, 1904, p. 508.)

VACHER, F. (1909). Report of County Medical Officer of Health on "Some recent Investigations regarding the propagation of Disease by Flies." Cheshire County Council.

VARWICH (1577). *Tractatlin von der Pestilenz.* (Cited by Mansa, 1872–3.)

VEEDER, M. A. (1898). The spread of typhoid and dysenteric diseases by flies. *Public Health*, (Amer. Publ. Health Assoc.), XXIV, 260–262.

VEEDER, M. A. (17th Sept., 1898). Flies as spreaders of disease in camps. *New York Med. Record*, 429–430.

VEEDER, M. A. (26th July, 1902). *New York Med. Record.*

WELANDER (1896). (Gonorrhœal ophthalmia conveyed by flies.) *Wien. klin. Wochenschr.*, No. 52. (Cited by Abel, 1899, p. 1070.)

WHERRY, W. B. (Nov., 1907). Insects and Infection. *California State Journ. of Medicine*, 281–285.

WILKERSON (1904). Flies as carriers of disease. *Mobile Med. & Surg. Journ.*, IV, 125–141.

WILSON, E. (1868). *Diseases of the skin*, p. 466. (Philadelphia.) (Cited by Nuttall, 1899.)

YERSIN—(1894). La peste bubonique à Hongkong. *Ann. Inst. Pasteur*, 662–667.

*——— (1863). "Gangrenous Fly." *Lancet*, II, 114.

*——— (25th Jan., 1873). "The Pestiferous Fly." *Lancet*, I, 156.

*——— (1884–5). "Les mouches considerées comme agents de propagation des maladies contagieuses des epidémies et des parasites." *Bull. Soc. Linn. Nord France.* No. 152, 215–217.

*——— (Aug., 1903). "The Fly Plague." *Lancet*, II, 418.

*——— (1908). Bulletin Chicago School of Sanitary Instruction. (Department of Health, City of Chicago.) 27th June.

*——— (1909). "The House-fly at the Bar. Indictment; guilty or not guilty? Evidence in the matter of the people *against* the common House-fly." *The Merchants Association of New York.*

*Anonymous.